Natomas Area
Groundwater Management Plan

Sacramento and Sutter Counties, California

Natomas Central Mutual Water Company

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1. Introduction

The Natomas Central Mutual Water Company (NCMWC) was formed in 1921 to divert water from the Sacramento River primarily for irrigation use, and also for limited municipal and industrial use. The municipal and industrial diversions are for non-domestic, i.e. irrigation, uses at Sacramento International Airport and the Sacramento Airport Special Planning Area (Metro Air Park) only (DWR, 1997).

NCMWC lies on reclaimed land, created in 1911 by an act of legislature and the formation of Reclamation District No. 1000 (RD 1000). Levees were constructed around the perimeter of RD 1000 to reclaim land from the floodwaters of the American and Sacramento Rivers, and a drainage system was constructed inside the levees to capture and discharge natural runoff. RD 1000 maintains 42 miles of levees around 81 square miles of area, in accordance with standards established by the U. S. Army Corps of Engineers and an assurance agreement with the State of California. The District also operates and maintains a large drainage system within its boundaries to dispose of agricultural and urban runoff. This system includes seven large pumping plants and 180 miles of canals and ditches.

1.1 Service Area and Distribution System

NCMWC is located on the east side of the Sacramento River, between the River and the City of Sacramento, in Sutter and Sacramento counties in the southwesterly portion of the North American Subbasin (Figure 1). RD 1000's boundary is basically the same as the NCMWC and Management Plan Area, which encompasses agricultural and urban land surrounded by the Sacramento River on the west, the Natomas Cross Canal on the north, the Pleasant Grove Canal and the Natomas East Main Drainage Canal on the east, and the American River on the south. NCMWC encompasses a total of approximately 55,000 acres, including approximately 5,400 acres of agricultural land that do not receive surface water from NCMWC; about 2,800 of those acres are irrigated exclusively with groundwater, and an estimated 600 acres are irrigated using private surface water rights separate from NCMWC's rights (American States Water Company, et al, 2006). The landowners within the boundaries of NCMWC are share-holders of NCMWC, a private company, as well as rate payers in RD 1000, a public entity.

Approximately half of the area within the NCMWC boundary is within Sacramento County, and is also within the management area of the Sacramento Groundwater Authority (SGA). SGA is a joint powers authority created to collectively manage the groundwater resources in Sacramento County north of the American River. NCMWC is a member of the Board of SGA and intends that this Plan will be fully integrated with the ongoing management actions and policies of SGA.

NCMWC serves approximately 250 landowners. NCMWC's service area includes the Sacramento International Airport and several residential developments, which are being planned as part of ongoing growth within and near the Sacramento area. Related to planned development, NCMWC is committed to the ongoing management of the adopted Natomas Basin Habitat Conservation Plan (HCP). The HCP establishes a multi-species conservation program to mitigate the potential loss of habitat of protected species that would result from urban development, operation of irrigation and drainage systems, and rice farming. The Natomas Basin Conservancy functions as plan operator for the HCP which was financed, directed, and completed by local landowners. Because of the integration of surface and groundwater and subsequent questions about the effect of both on species dependent upon water supply, the HCP calls for long-term dedication of mitigation lands which will be serviced by NCMWC and RD 1000 in an effort to properly provide for species.

NCMWC's three primary river diversion points are located on the Sacramento River. NCMWC also diverts water in two locations from the Natomas Cross Canal, which is located along its northern boundary. Water diverted from the Cross Canal is subsequently conveyed from north to south, while water diverted from the Sacramento River is generally conveyed from west to east, then south.

NCMWC's distribution and conveyance system includes approximately 130 miles of canals and laterals, with eighty-four (84) pumps in over 35 internal locations; in addition, NCMWC makes use of a portion of RD 1000's approximately 180 miles of drainage ditches for distribution of agricultural water supplies. NCMWC completed the installation of a recirculation system in 1986 to improve water quality in the Sacramento River, to reduce river diversions, and to increase overall efficiency. The recirculation system includes 16 pumping stations that recapture water for re-use by discharge directly into fields or back into the main irrigation canals.

1.2 Agriculture

Rice is the predominant crop grown within NCMWC's service area. Other crops have included tomatoes and sugar beets, as well as wheat and safflower that are rotated with rice and tomatoes. Rice typically accounts for approximately 60 percent of the irrigated acreage on an annual basis. Agriculture in NCMWC is generally under varying pressure to convert to suburban land use as part of regional growth in the greater Sacramento region.

As is the case with most of the other water providers in the Central Valley, water requirements are typically highest during the summer months (July and August) due to crop requirements in the area's hot, dry climate. Irrigation demand for rice is also high early in the growing season, partly due to the flooding of rice fields for planting, as well as to meet the needs of other crops. Annual cropping patterns have remained fairly constant over the last few decades, other than in response to farm programs in the early 1980's. As a result, water requirements and associated diversions have therefore been more a function of water year type and climate than changes in cropping.

In response to increasingly stringent limitations on burning, some of the rice-growing landowners flood portions of their fields to decompose leftover rice straw. This practice provides additional winter habitat for waterfowl above that which has been available within the Sacramento Valley since the development of agriculture. Approximately 7,000 acres have been flooded in the past, a trend that is expected to continue or increase assuming that other options (including the sale of stubble for ethanol production) are not determined to be more economically feasible

As parts of the Natomas area urbanize in the future, NCMWC will supply water for increasing municipal and industrial uses, as well as serve water for environmental purposes to natural habitat and open space, potentially reducing the water requirements for irrigation.

1.3 Water Supplies

The vast majority of irrigation water requirements is met through surface water supply, although groundwater is used in drought years on an individual grower basis, as well as through agreements with NCMWC.

Surface Water - A water right settlement contract with the Bureau of Reclamation, entered on April 29, 1964 and renewed in 2005, provides a base supply of 98,200 acre-feet (af) which can be diverted during April through October, and a project supply of supplemental water of 22,000 af (total of 120,200 af). The settlement provided that NCMWC could divert water for municipal and industrial purposes year-round. In addition to the contract water, NCMWC has a permit to divert up to 10,000 af from the Sacramento River during the fall and winter for wetlands and rice straw decomposition. NCMWC operates three primary river diversion points along the Sacramento River; surface water is also diverted at two locations from the Natomas Cross Canal on the northern boundary of NCMWC. Surface water diverted from the Sacramento River generally flows from west to east, then south, while diversions from the Natomas Cross Canal flow from the north to south.

In addition to its primary surface water supplies, NCMWC has water rights to several of the drainage facilities located within or bordering its boundaries including RD 1000 East Drain, RD 1000 West Drain, and RD 1000 Main Drain.

Based on surface water delivery data for shareholder lands in NCMWC since 1965, annual diversions during the irrigation season have ranged between 63,600 af in 1967 and about 116,000 af in 1975. The average diversion amount during that time period was about 88,400 af. Diversions during the fall and winter are not metered but are expected to approximate the 10,000 af allotted to NCMWC.

Tailwater and Re-Use/Recirculation **-** In recent years, NCMWC has relied increasingly upon recovered tailwater as an alternate supply to its Sacramento River entitlements. The availability of this tailwater has been a result of water initially used by landowners within NCMWC, although some tailwater is available from the western portion of NCWMC which is adjacent to the Sacramento River. Approximately 30,000 acre-feet of tailwater are utilized annually. Continued re-use and recycling efforts are expected to be influenced by an increasing need to manage salinity and other constituents that affect crop productivity and sustainability.

NCMWC completed the installation of a recirculation system in 1986 for several intended purposes including improvement of water quality for the City of Sacramento by reducing tailwater discharge to the River, reduction of River diversions, and an increase of overall efficiency within its boundaries. The recirculation system has provided a number of benefits:

- improve water quality discharge from RD 1000 pumping plants into the Sacramento River,
- reduce pumping during the summer months by RD 1000,
- increase water availability to parts of the service area with a history of "poor service",
- reduce costs to customers (drain rate) who install drain pumps to receive drain water exclusively,
- reduce diversions and water costs to the Central Valley Project Improvement Act (CVPIA) Restoration Fund for project water,
- improve water conservation practices through the installation and operation of a Company-wide recycling program,
- allow greater flexibility for growers in method and timing of water application and crop selection without the institution of a metered water charge system,
- increased use of the RD 1000 drainage system as a conduit to a larger number of acres, to increase the water use efficiency of NCMWC, and
- partially "closing" the basin (restricting return flows to the river), allowing NCMWC to utilize not only its own drain water, but also the drain water from other river diverters and groundwater users in the sub-basin; this includes a portion of the City of Sacramento as well as Sacramento International Airport.

The recirculation system includes 30 pumping stations at 16 locations that recapture water for reuse either directly into fields or back into the main irrigation canals. The system also includes two re-lift pumps at two locations that lift drain water from the Southern service area to the Central service area and then from the Central service area to the Northern service area. During a normal irrigation season, all agricultural drainage water is recirculated through the end of the rice season which ends between August 15 and September 1. This management effort maximizes water re-use as a standard operational procedure by NCMWC.

NCMWC is also interested in developing more opportunities for re-using water in the form of reclaimed wastewater as development continues in the area. This would promote the use of non-potable water for uses that do not require potable water, possibly including irrigating parkways, public parks, school and sports fields, and for irrigation, rice-straw decomposition and managed wetlands.

Groundwater **-** A total of 296 wells were reported to be located within the Plan Area, in the Sacramento River Basinwide Water Management Plan (DWR, 2003), based on the number of Well Completion Reports filed with DWR for irrigation wells (94 wells), domestic wells (125 wells), municipal and industrial wells (16 wells), and other wells (61 wells). Recent efforts associated with levee improvements indicate the total number of wells to now slightly exceed 350. While the great majority of wells are still for individual domestic purposes some groundwater is used in conjunction with surface water and drain-water recycling to meet irrigation water requirements, as well as individual domestic and other generally small water requirements. One Company-owned well is used to provide additional capacity in a small area at the southern end of the overall service area. The other privately-owned wells are used independently of NCMWC operations, predominately for habitat or for irrigation supply during drought situations.

Storm Water - Additional water may be available as a result of detention basins constructed by development interests. Such basins are required by RD 1000 to control the additional runoff created by new urban development. Such runoff is anticipated to generate as much as 25,000 afy of groundwater recharge from the detention basins, although an estimated 5,000 afy might be beneficially used for crops. Detention basins are new to the service area and will be a point of study, for both quantity and quality, of this Groundwater Management Plan.

1.4 Groundwater Management, Assembly Bill 3030, and State Bill 1938

In 1992, the California State Legislature adopted Assembly Bill 3030 (AB 3030) and in 2002 the Legislature enacted State Bill 1938 (SB 1938). SB 1938 provides that adoption of a groundwater management plan will be a prerequisite to obtaining funding assistance for groundwater projects from funds administered by DWR. These two pieces of legislation have been incorporated into the State Water Code, Section 10753, to encourage local public agencies/water purveyors to voluntarily adopt formal plans to manage groundwater resources within their jurisdictions. NCMWC has prepared this update to its originally drafted Groundwater Management Plan to be compliant with the technical and policy aspects of the Water Code that resulted from AB 3030 and SB 1938.

The potential components of a groundwater management plan listed in Section 10753 of the Water Code consist of:

- control of saline water intrusion
- identification and management of wellhead protection areas and recharge areas
- regulation of the migration of contaminated groundwater
- administration of a well abandonment and well destruction program
- mitigation of conditions of overdraft
- replacement of groundwater extracted by water producers
- monitoring of groundwater levels and storage
- facilitating conjunctive use operations
- identification of well construction policies
- construction and operation by the local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects
- development of relationships with state and federal regulatory agencies
- review of land use plans and coordination with land use planning agencies to assess activities, which create a reasonable risk of groundwater contamination.

Amendments to the Water Code regarding the implementation of local groundwater management plans as a result of SB 1938 did not alter the potential components of a local groundwater management plan, as listed above, but did add the following provisions:

- The local agency, in preparing a groundwater management plan, shall make available to the public a written statement describing how interested parties may participate in developing the plan. For that purpose, the local agency may appoint, and consult with, a technical advisory committee consisting of interested parties.
- In order to qualify for funding assistance for groundwater projects, for funds administered by DWR, a local agency must accomplish all the following relative to groundwater management (California Water Code 10753.7(a)):

    - Prepare and implement a groundwater management plan that includes basin management objectives for the groundwater basin that is subject to the plan.
    - Include groundwater management components that address monitoring and management of water levels, groundwater quality degradation, inelastic land subsidence, and changes in surface flows and quality that either affect groundwater or are affected by groundwater pumping.

- Include provisions to cooperatively work with other public (and presumably private) entities whose service area or boundary overlies the groundwater basin.
- Include mapping of the groundwater basin, as defined in DWR's Bulletin 118, and the boundaries of the local agency subject to the plan, plus the boundaries of other local agencies that overlie the basin.
- Adopt monitoring protocols designed to detect changes in groundwater levels, groundwater quality, inelastic land subsidence (for basins where subsidence has been identified as a potential problem), and flow and quality of surface water that either directly affect groundwater, or are directly affected by groundwater pumping.

In summary, NCMWC has prepared this updated Plan to be compliant with the AB 3030 and SB 1938 requirements embedded in the Water Code as part of its interest in developing and sustaining reliable water supplies. To ensure the reliability of groundwater supplies to meet part of existing and projected water requirements, this Plan establishes a set of objectives for groundwater and interrelated surface water in the Plan area, continues the originally adopted components of groundwater management, and expands those components as appropriate. Some of the potential groundwater management activities listed in the Water Code are already being investigated and actively implemented by NCMWC. The historic focus of groundwater management has been on water supply, quantity and quality, to avoid conditions of overdraft, primarily by developing surface water supplies that augment local groundwater supplies and thus contribute maintenance of groundwater levels and storage. While that focus is continued in this updated Plan, and others added as appropriate, the potential management provisions not implemented are more focused on groundwater quality and contamination issues that are not relevant to the Plan Area, e.g. control of saline water intrusion, and control or cleanup of groundwater contamination.

Finally, although this management plan is not, strictly speaking, an AB 3030 or SB 1938 plan as discussed herein, it is intended to be essentially equivalent. Landowners, represented by the board of NCMWC, have created this updated Plan, and will be responsible for its implementation. In December 1997, NCMWC adopted an original resolution of joint intention to draft a Groundwater Management Plan pursuant to Water Code Section 10753 (AB 3030). That resolution was followed by an identical resolution by RD 1000 in December, 1997. After several years of subsequent coordination and planning, and in recognition that groundwater management is more directly related to water supply, and not so directly related to drainage and flood protection, NCMWC assumed leadership in the drafting and in the intended adoption and implementation of a groundwater management plan in 2002.

Originally, the joint resolution provided for RD 1000's governing leadership as a public agency, and for NCMWC's programmatic leadership as the water supply entity within the co-located service areas. NCMWC's Board was to assume responsibility for the design and implementation of groundwater management programs and the RD 1000 Board was to provide the public governance for the overall plan. The area to be included in the management plan (Plan Area) was inclusive of the service area of RD 1000 (Figure 1).

With the assumption of leadership in drafting the original plan by NCMWC, and this update to that Plan, there is a resultant lack of a public entity to assert its role as a local groundwater management entity; such was one of the requirements within AB 3030 for the adoption of a "local" groundwater management plan. Consequently, although the original plan and this update have been drafted in concert with the principles and components of AB 3030 and SB 1938, it is strictly speaking not a 3030 Plan. However, again based on the content and the integration of AB 3030 and SB 1938 components, and further based on the development by local landowners over a large local area, it is the intent of NCMWC that this updated Groundwater Management Plan is the effective equivalent, i.e. adopted by a private rather than a public agency, of an AB 3030 groundwater management plan, as intended in Water Code Section 10753.

The balance of this Plan is organized to first establish a set of management objectives for the area; to then describe existing groundwater conditions; and to finally present a set of groundwater management elements which, in aggregate, comprise this overall Groundwater Management Plan.

2. Management Objectives (Goals) for the Area

The NCMWC diverts water for use within its service area from the Sacramento River. Within the Plan Area, some individual land owners pump water from wells for irrigation and domestic purposes, but the surface water diversions by NCMWC remain the predominant source of water supply in the Plan Area.

In cooperation with adjacent water purveyors and the Department of Water Resources, NCMWC participated in a feasibility evaluation of conjunctive use of Sacramento River water and local groundwater in the American Basin (DWR, 1997). Most of the potential components of groundwater management were addressed in that evaluation, and the NCMWC Board of Directors subsequently determined that Natomas would initiate development of groundwater supplies to integrate with historical surface water supplies for overlying beneficial use within its service area. That activity is expected to result in several benefits to the availability of water resources in the region from both a quality and a quantity standpoint, complemented by a more complete understanding of aquifer and river interaction in the area.

This Plan provides a management framework for maintaining a high quality, reliable, and sustainable supply of groundwater within NCMWC, built on continuation of conjunctive use operations to meet local requirements while also providing opportunities to participate in other water supply programs within the sustainable yield of local surface water and groundwater resources. Management objectives intended to be achieved in the Plan Area via implementation of this plan thus include the following:

- Development of Local Groundwater for Water Supply
- Avoidance of Overdraft and Associated Undesirable Effects
- Preservation of Groundwater Quality
- Preservation of Interrelated Surface Water Resources

Quantitatively, the preceding goals translate into general preservation of groundwater levels and quality, including fluctuations through seasonal demands and local hydrologic variations (wet and dry periods), as discussed in this Plan, based on groundwater level and quality monitoring as included in this Plan. Specific issues to be considered include evaluation of available groundwater storage capacity, determination of sustainable groundwater yield, assessment of river-aquifer interconnection, and avoidance of land subsidence.

Over the long term, as urbanization of the Natomas area expands and agricultural water demands decline, NCMWC will seek to convert some of its conjunctively used surface and groundwater resources from irrigation supply to municipal supply in cooperation with other local entities whereby some of Natomas' water will be part of local, regional, or State water supplies. The NCMWC is also interested in utilizing its conjunctive use policy to incorporate water transfers. Such water transfers might become possible as part of SGA programs or through the DWR Drought Water Bank, for example, during dry periods. Within the overall context of this Plan, the NCMWC will determine if transfers from their service area would be feasible while maintaining a reliable water supply to its customers and minimizing groundwater impacts that could potentially result from water transfers.

Ultimately, this Plan provides a management framework for maintaining a high quality, reliable, and sustainable supply of groundwater, integrated with ongoing surface water supplies, within the NCMWC service area. By implementing this Plan, NCMWC envisions the meeting of local water requirements with sustainable water supplies while also supporting regional basin management objectives directed toward the sustainability of groundwater supplies.

3. Groundwater Basin Conditions

3.1 North American Groundwater Subbasin

The Plan Area is located in the southeastern portion of the Sacramento Valley Groundwater Basin, in the southwestern part of the North American Groundwater Subbasin (Basin No. 5-21.64 in DWR Bulletin 118-2003); the latter is one of 18 subbasins in the Sacramento Valley Groundwater Basin. The North American Subbasin is located along the eastern edge of the Sacramento River Valley and encompasses about 351,000 acres in Sutter, Placer, and Sacramento counties. The North American Subbasin is bounded by the Bear River on the north, by the Feather and Sacramento Rivers on the west, by the American River on the south, and by the approximate edge of the alluvial aquifer in the Sierra Nevada foothills on the east (DWR, 2006). The North American Subbasin and adjacent groundwater subbasins are shown on Figure 1.

3.2 Geologic Setting – Water Bearing Formations

DWR's Bulletin 118 (2006) and Feasibility Report (1997) include descriptions of the subsurface water bearing materials in the North American Subbasin. Schematically illustrated in Figure 2, from deepest/oldest to shallow/youngest, those materials are known as the Mehrten Formation, the Laguna and Turlock Lake Formations, the Riverbank and Modesto Formations, and Flood Plain Deposits and Alluvium. Surface outcrop locations for those materials are illustrated in Figure 3. Within those water bearing materials, the base of fresh water deepens westward from about 400 feet below sea level near the Sierra Nevada foothills to over 1,200 feet below sea level at the axis of the Sacramento Valley (DWR, 1997).

Mehrten Formation – The oldest freshwater bearing sediments in the subbasin are known as the Mehrten Formation, a sequence of late Miocene through middle Pliocene fragmented volcanic rocks, that unconformably overlie marine and brackish-water sediments of Eocene age. The Mehrten Formation can be divided into two distinct units based on composition, and is exposed only on the eastern side of the subbasin, east of the District near Lincoln and south toward Roseville. One of these units is a sedimentary unit consisting of gray to black andesitic sands and gravels deposited by fluvial activity and originating from andesitic source rocks in the Sierra Nevada. The other distinct unit, which is interbedded with intervals of the previous unit, is composed of dense, hard, gray tuff breccia derived from volcanic eruptions in the Sierra Nevada. The Mehrten Formation provides highly permeable intervals of sand and gravel as well as confining layers composed of the tuff breccia intervals. Depending on location, the Mehrten Formation is between 200 and 1,200 feet thick, and wells completed in the sand and gravel units have reported pumping capacities of over 3,000 gallons per minute (gpm).

Laguna and Turlock Lake Formations – The Pliocene-age Laguna Formation and the early Pleistocene-age Turlock Lake Formation unconformably overlie the Mehrten Formation. The Turlock Lake Formation can be distinguished from the Laguna Formation in outcrop due to the presence of a preserved clay soil horizon, which had been stripped by erosion in the Laguna Formation. The Laguna Formation outcrops very rarely in the subbasin, surfacing near Wheatland and towards the east and south of the North American Subbasin in small areas. The Turlock Lake Formation outcrops in the southeast of the subbasin, and in a small area just southwest of Sheridan. The Laguna and Turlock Lake formations are lithologically indistinguishable in the subsurface, both consisting of a heterogeneous mixture of tan to brown interbedded silt, clay, and sand with a few gravel lenses that are poorly sorted and have relatively low permeability. The two formations have a combined thickness of less than 200 feet. Due to the predominantly fine-grained character of these two formations, wells completed in them reportedly have low to moderate yields, usually less than 1000 gpm.

Riverbank and Modesto Formations – The Pleistocene-age Riverbank and Modesto formations are the most widely exposed geologic units in the study area; they unconformably overlie the Turlock Lake, Laguna, and Mehrten formations and pre-Cretaceous metamorphic and igneous rocks. The Riverbank and Modesto formations are lithologically indistinguishable in the subsurface, composed of mixtures of silt, sand, gravel, and clay that are very heterogeneous laterally and vertically. The combined thickness of these two formations can be up to 75 feet. As a whole, these two formations are moderately permeable, but include highly permeable coarse zones.

Flood Basin Deposits and Alluvium – These sediments are also known as the Younger Alluvium as they are the youngest geologic units in the subbasin. Laterally extensive outcrops of the Alluvium deposits occur along the Bear, Feather, and Sacramento Rivers, while the Flood Basin deposits outcrop on the western margin of the subbasin; immediately east of the Sacramento River. The Alluvium is composed of stream channel deposits, originating in the channels of active streams as well as overbank deposits of those streams, terraces, and local dredge tailings. Flood Basin deposits consist primarily of poorly drained silts and clays, although interbedded local lenses of sand and gravel may occur from the deposition of migrating ancestral river channels. The thickness of each of these units may be up to 100 feet. The sand and gravel zones of the Alluvium deposits are highly permeable and yield significant quantities of water to wells, whereas the Flood Basin deposits have low permeability and generally yield low quantities of water to wells.

The geologic units described above have been grouped and separated into two aquifer units in the NCMWC area. The upper aquifer includes saturated Laguna Formation and younger unconfined sediments (Riverbank and Modesto Formations, and Flood Basin Deposits and

Alluvium) consisting of generally thin and laterally discontinuous sands and gravels separated by thick sequences of clay strata. The lower aquifer consists of Mehrten Formation continental deposits, including a significant amount of fine-grained materials. Sand and gravel units are generally thicker than the upper aquifer, but are still laterally discontinuous. DWR has been monitoring a site near the southern border of the District with multiple completion monitoring wells, where water levels show a vertical gradient between the two aquifer units, and some hydraulic interconnection. Most of the production wells located throughout the District are thought to be completed in the upper aquifer. With time, implementation of this Plan is intended to produce a more thorough definition of well construction and completions throughout the District.

3.3 Groundwater Elevations

Prior to the 1960's, groundwater was the sole source of water supply in most parts of the North American Subbasin. A strong dependence on groundwater existed in the southern central portion of the Subbasin, generally east of NCMWC, resulting in groundwater declines at an average rate of up to about one and a half feet per year for about 50 years, through the 1980s to mid-1990s. The introduction of surface water sources has subsequently resulted in stabilization to some recovery of groundwater levels, although an elongated groundwater depression remains to the east of NCMWC, in the McClellan Air Force Base area in northern Sacramento County where groundwater levels are tens of feet lower than in surrounding areas. Throughout the North American Subbasin, groundwater levels continue to fluctuate seasonally and through varying climatic conditions.

In the vicinity of the Plan Area, DWR has historically monitored over 100 wells for water level elevations. Approximately 25 of those wells are located within the Plan Area, with a composite period of record from 1932 to 2009. In and near the Plan Area, groundwater elevations are typically higher to the north and west, and lower to the south and east in both aquifer units. A collection of representative long-term hydrographs illustrates the history of groundwater level fluctuations in the Plan Area (Figure 4). In general, groundwater levels in the western portion of the Plan Area have been historically high in the upper aquifer (often within 10-20 feet of ground surface) due to recharge from precipitation and infiltration from excess irrigation water. Hydrographs for wells on the east side of the Plan Area graphically depict the historical decline in water levels associated with the groundwater depression east of the Plan Area. Groundwater levels have stabilized to the immediate east of the Plan Area (well 10N/5E-8L2) since the 1980s. Immediately inside the Plan Area, historical groundwater levels did not decline as steeply as farther east (well 9N/4E-1R1, as contrasted to wells 10N/5E-8L2 and 9N/5E-21M1). In the western portion of the Plan Area, water levels have been high and have exhibited a relatively flat trend as illustrated by the groundwater elevation hydrographs for wells located in western half of the Plan Area. This portion of the Plan Area is unaffected by the pumping depression to the east and more affected by seasonal conditions and climatic fluctuations.

The Department of Water Resources has constructed five multiple completion monitoring wells in the North American Subbasin in order to monitor discrete intervals within the aquifers (DWR, 1997). Two of these wells, AB-3 and AB-4, are located in the Plan Area (Figure 5). Generally, the upper aquifer system has been found to exhibit unconfined aquifer characteristics. Confinement has been found to increase with depth in the lower aquifer (DWR, 1997). The lower aquifer zone exhibits delayed responses to imposed stresses in the upper aquifer, indicating some hydraulic interconnection between these water-bearing strata.

Groundwater level data in the Plan Area region is maintained by DWR's Central District. Data from at least 28 wells, 19 of which are within the Plan Area boundaries (Figure 5), were used to prepare water level hydrographs for each well, and for preparation of groundwater elevation contour maps in 1977, 1984, 1994, and 1996 (Figures 6, 7, 8, and 9). These particular years were selected to show the effects of drought conditions in 1977 and 1994, and subsequent recoveries of water levels in 1984 and 1996. Groundwater elevation contour maps in the North American Subbasin are also presented for Spring 2008 to show recent conditions on a more regional scale (Figures 8).

The contour map of Spring 1977 groundwater levels (Figure 6) shows the drought effect on the groundwater levels in the Natomas area. The contour map shows a west to east groundwater flow direction away from the Sacramento River. The groundwater gradient west of the north-south trending Highway 99, which essentially bisects the Plan Area, is fairly flat (about 1 to 2 feet per mile) as compared to the area east of Highway 99, which is relatively steep (about 2 to 8 feet per mile). Groundwater elevations range from about 10 to 15 feet, mean sea level (msl) in the western portion of the Plan Area to about -20 feet, msl in the eastern portions of the Plan Area. The low groundwater elevations in the eastern portion of the Plan Area appear to be influenced by a groundwater pumping depression to the east. Groundwater elevations, which are historically uniform and high in the Plan Area, were lower by as much as ten feet or more at individual wells during this drought period compared to wet periods.

The contour map for Spring 1984 (Figure 7) shows the multiple year recovery of groundwater elevations since the 1976-77 drought years. This particular year was chosen for illustration because hydrographs indicate that groundwater levels reached their post-drought highs. The contour map exhibits groundwater flow direction to be from the west to the east. Gradients of less than 2 feet per mile are present in the central and southern parts of the Plan Area, steepening to over 15 feet per mile in the east and northeast. Groundwater elevations range from 15 to 20 feet, msl in the west and northwest to about -15 feet, msl to the east in the Plan Area. A groundwater pumping depression still exists to the east of the Plan Area.

The map of Spring 1994 contours (Figure 8) shows a significant decline in groundwater elevations from 1984 due to the sustained 1988 through 1992 drought period. Groundwater flow directions in this time period were from west to east on the eastern half of the Plan Area, east of Highway 99, but were mainly southwest to southeast in the western half of the Plan Area. Groundwater level gradients range greatly from the western half to the eastern half of the Plan Area, from very flat (less than one foot per mile) in the west to as steep as 20 feet per mile to the east. Groundwater elevations range from between 5 to 15 feet, msl in the western half of the Plan Area, to as low as -20 feet, msl on the central-eastern border of the Plan Area. The groundwater pumping depression is present to the east of the Plan Area during this time period.

The map of Spring 1996 contours (Figure 9) indicates the rapid recovery of groundwater levels due to above-normal precipitation in 1995 and 1996. Groundwater elevations increased as much as eight feet in some wells. Groundwater flow directions are to the southeast on the western side of Highway 99 and to the east on the eastern side of Highway 99. The groundwater level gradients are relatively stable throughout most of the Plan Area, ranging between 1 to less than 4 feet per mile, steepening in the east to 15 feet per mile. Groundwater elevations range from -5 feet, msl in the east to over 20 feet, msl in the northwest. Groundwater levels are still depressed in the eastern portion of the Plan Area due to the pumping depression to the east.

Groundwater elevations in the vicinity of the Plan Area on a more regional scale in the North American Subbasin are depicted in Figure 10. Figure 10 shows contours of equal groundwater elevation for Spring 2008. Although only nine wells in the Plan Area had available water level data for this contour map, the water levels in the Plan Area appear relatively stable to the north and west, and a steep decline on the eastern edge of the Plan Area is still pronounced due to the depressed water levels in northern Sacramento County. Groundwater flow directions are generally from the north to the southeast in the Plan Area. The groundwater level gradient ranges from a low of about 1 foot per mile in the northwestern portion of the Plan Area to about 12 feet per mile near the eastern border of the Plan Area. Groundwater elevations in the Plan Area range from 20 feet, msl in the north, to less than 10 feet, msl in the central portion, to possibly as low as -20 feet, msl in the southeastern corner of the Plan Area. The contour map clearly shows the groundwater pumping depression roughly three miles east of the southeast corner of the Plan Area. The groundwater pumping depression was already present by the Spring of 1960 and, by 1997, groundwater elevations had been drawn down to more than 40 feet below sea level, a decline of more than 100 feet from pre-development water levels (Montgomery Watson, 1997, and DWR, 1997). The effects of this pumping depression are seen in the eastern and southeastern parts of the Plan Area in each of the years contour maps were produced (Figures 6 to 10).

3.4 Groundwater Quality

Groundwater quality data is available from DWR and the USGS for several wells within and outside the Plan Area. Most groundwater quality data in the Plan Area are located near the boundaries of NCMWC. Very little groundwater quality data is available for the interior of the Plan Area. Groundwater quality for the area was summarized in the Feasibility Report for the American Basin Conjunctive Use Project (DWR, 1997). The report identified numerous constituents in the western portion of the Plan Area, west of Highway 99, which might be harmful to certain crops; those included total dissolved solids (TDS), chloride, sodium (and associated sodium adsorption ratio), bicarbonate, boron, iron, manganese, arsenic, and temperature. The report stated that these could be controlled and made safe for irrigation use in the Plan Area by blending surface water with groundwater in ratios of 2:1 to 3:1.

Total Dissolved Solids (TDS) at concentrations above 1000 mg/L are considered undesirable for drinking water supplies, with most desirable concentrations below 500 mg/L (the upper and lower limits of secondary MCLs for drinking water). TDS concentrations above 450 mg/L can be undesirable for irrigation water under certain conditions, again depending on the ionic composition of the water. Elevated TDS concentrations in groundwater may lead to soil salinity accretion where low-volume irrigation practices are used in low-permeability soils with high evapotranspiration rates (DWR, 1997). TDS data for groundwater wells in the region of the Plan Area is available from the USGS between 1961 and 2008; however, most wells report only one measurement during that time. A map of maximum TDS concentrations for the well’s reported period of record (Figure 11), shows that TDS concentrations above the drinking water MCL of 500 mg/L have occurred in the southern edge of the Plan Area. In that area, TDS has exceeded 500 mg/L in five different wells, only one of which exceeded the upper drinking water MCL of 1,000 mg/L (at 1,140 mg/L). Two wells in the central part of the Plan Area, one on the eastern border and the other on the western border, also exceed 500 mg/L, as do two more north and west of the Plan Area. The Plan Area does not have a TDS problem, as wells on record have maximum TDS concentrations less than 500 mg/L and only one sample on record in the Plan Area has exceeded 1,000 mg/L.

Chloride concentrations above 106 mg/L have been reported to be potentially undesirable for some crops, such as fruit orchards (CVRWQCB, 2008). For drinking water, the recommended and upper secondary MCLs are 250 and 500 mg/L, respectively. Irrigating with water containing elevated concentrations of chloride may result in the accumulation of salts in the root zone. Citrus, stone fruit, and almond orchards can be damaged if irrigation water with elevated chloride is applied by sprinklers, and this damage increases under conditions of high evapotranspiration (DWR, 1997). Chloride concentration data is available in the Plan Area vicinity between 1950 and 2008, but again most wells only report one or two measurements. A map showing the maximum chloride concentrations for each well’s period of record is presented in Figure 12. This map shows only two wells, located in the southern and eastern portions of the Plan Area, with chloride concentrations that exceed 106 mg/L but are well below 250 mg/L.

Sodium occurs naturally in groundwater because most rocks and soils contain sodium compounds from which sodium is easily dissolved. The Central Valley Regional Water Quality Control Board published an Agricultural Water Quality Limit of 69 mg/L for sodium (CVRWQCB, 2008). There is no quantitative drinking water standard for sodium. Figure 13 illustrates the maximum concentration of sodium in groundwater between the period of record 1953 and 2008, indicating areas of sodium concentrations that have historically exceeded the agricultural water quality limit (69 mg/L) in the southern, northwestern, and central eastern portion of the Plan Area. The highest sodium concentration measured in the Plan Area was 130 mg/L, but the majority of the wells in the Plan Area have concentrations below 69 mg/L. The elevated concentrations in the north and western Plan Area may be influenced by upgradient occurrences, where a maximum concentration of sodium has reached 170 mg/L north of the Plan Area.

Boron, with an agricultural water quality limit of 0.7 mg/L (CVRWQCB, 2008) and a Basin Plan objective of 2.0 mg/L (CVRWQCB, 2008a), is very low in the Plan Area for the period of record available between 1953 and 2008. Although data in the center of the Plan Area is sparse, most maximum boron concentrations are between 0.1 and 0.4 mg/L, with a complete range of concentrations between 0.053 mg/L in the east to 1.6 mg/L to the west along the Sacramento River (Figure 14). Higher concentrations of boron (greater than 2 mg/L) exist to the west of the Sacramento River and the Plan Area.

The agricultural water quality limit for ***iron*** is 5.0 mg/L, and the secondary MCL for drinking water is 0.3 mg/L (CVRWQCB, 2008). Iron concentration data in the central Plan Area is sparse, but most iron concentrations along the edges of the Plan Area are below 0.3 mg/L (the secondary drinking water MCL). Figure 15 shows maximum iron concentrations from 1957 to 2008 in and around the Plan Area. Three wells located along the southern border of the Plan Area had maximum iron concentrations at or above 0.3 mg/L, with the highest concentration in the Plan Area of 2.37 mg/L. None of the wells in the Plan Area exceed the agricultural water quality limit for iron of 5.0 mg/L.

The secondary drinking water MCL for ***manganese*** is 0.050 mg/L and the agricultural water quality limit is 0.20 mg/L (CVRWQCB, 2008). Manganese concentration data in the vicinity of the Plan Area is available for a record between 1965 and 2008, with concentrations above 0.20 mg/L seen along the Sacramento River (Figure 16). In the Plan Area, many wells on the west and southern edges reported manganese concentrations above 0.20 mg/L, as high as 9.83 mg/L, but further east of the River groundwater concentrations remain below 0.20 mg/L, with many of these locations below 0.050 mg/L.

Elevated ***arsenic*** concentrations in water can be toxic to humans and can cause crop damage. The agricultural water quality limit for arsenic is 100 ug/L, and the primary MCL for drinking water is 10 ug/L (CVRWQCB, 2008). Arsenic concentration data available between 1967 and 2008 have exhibited levels above the drinking water standard along the Sacramento River on the southwest and south sides of the Plan Area, as well as to the east of the Plan Area (Figure 17). All of the wells with arsenic data in the Plan Area have maximum concentrations below the agricultural water quality limit of 100 ug/L, with the highest concentration of arsenic in the Plan area at 86.2 ug/L, located near the southern border of the Plan Area.

Immediately east of the Plan Area, groundwater beneath McClellan Air Force Base is contaminated by organic solvents in four areas on the base. The contamination has reached depths greater than 150 feet beneath the base, and to 280 feet at one location. Some contaminants have migrated offsite, to the south, towards City of Sacramento wells (Montgomery Watson, 1993). Remediation of this contamination is ongoing. Mobilization of McClellan groundwater quality constituents into the Plan Area is highly unlikely in light of the prevailing groundwater gradient from west to east and the objective of this Plan to maintain pumping within sustainable yield and avoid overdraft, e.g. lowering of groundwater levels that could reverse that gradient.

Other groundwater quality constituents of potential interest include nitrate, bicarbonate, fluoride, and temperature. Due to a lack of data for these constituents within the Plan Area and the occurrence of low maximum concentrations (below drinking water standards or agricultural limits) for available data, these constituents are not currently a concern.

3.5 Groundwater Pumpage

There is no ongoing effort to regularly estimate the amount of groundwater pumping the Plan Area. Recent efforts associated with levee improvements have identified a total of more than 350 wells within the overall Plan Area, more than half of which are individual domestic wells located on the western and eastern boundaries of the Plan Area, i.e. along the Sacramento River and along the Pleasant Grove Creek Canal and Natomas East Main Drainage Canal. Available records indicate that most of those wells are completed to depths less than 300 feet. Pumping from them is not metered or otherwise recorded; one estimate in 2004 indicated total pumping from those wells to be between 100 and 500 acre-feet per year.

Higher capacity irrigation wells, completed to depths of 300 feet and deeper, are located throughout the Plan Area, but most notably to the northeast and east-central parts of the Plan Area beyond the service area of the NCMWC distribution system. In some cases, irrigation wells are utilized to provide groundwater to parcels that also have access to surface water deliveries from NCMWC or from other diversions. For the most part, however, irrigation wells provide the only water supply to lands within the Plan Area but beyond the NCMWC surface water distribution system.

In its American Basin Conjunctive Use Feasibility Report (1997), DWR reported that irrigation wells in the area were typically equipped to pump between 1,000 and 2,500 gpm, with an overall average of about 1,900 gpm. DWR estimated that pumping for irrigation in the Natomas area north of Interstate 5 had averaged about 19,000 afy over the 20 year period from 1970-1990. Updated work for the entire Natomas area over the last several years has reported estimated pumping to be about 28,000 to 30,000 afy.

In addition to the privately owned irrigation wells, the Natomas Basin Conservancy has an estimated 13 irrigation wells for water supply to its various lands located in the northwest, central and east-central, and southwest parts of the overall Plan Area. For the most part, those wells represent supplemental water supplies to complement or augment either surface water deliveries from NCMWC or surface water from other sources. Three of the NBC wells represent the only water supplies to the individual parcels where they are located. Pumpage from the NBC wells is not recorded.

One of the objectives of this Plan is to better define the spatial distribution and estimated amounts of groundwater pumping as part of the larger goals to continue development and use of groundwater within the sustainable yield of the aquifer system, to continue conjunctive use of surface water supplies with local groundwater, and to participate in groundwater substitution or other similar, e.g. Phase 8 water transfer programs.

3.6 Land Subsidence

Land subsidence is the lowering of the ground surface through compaction of compressible, fine-grained strata. It is most often caused by pumping and subsequent dewatering from unconsolidated, interbedded aquifer-aquitard systems, but can also be caused by other factors such as extraction of oil and gas. Compaction can be fully reversible (elastic) or permanent (inelastic). Elastic compaction and expansion generally occur in response to seasonal groundwater level fluctuations. Inelastic compaction is most likely to occur when groundwater levels reach historical lows, potentially resulting in prolonged dewatering of clay units. Although land subsidence is most likely to occur in the areas with the largest groundwater level declines, some areas are more susceptible to subsidence than others because of geologic conditions.

Monitoring of land subsidence has been limited in the North American Subbasin. Historically, land subsidence was monitored along transects by comparing periodic spirit level surveys conducted by the USGS and the National Geodetic Survey (NGS). In the mid-1980s, a transition was made from spirit level surveys to global positioning system (GPS) surveys. GPS surveys were conducted in the southern portion of the Sacramento Valley from 1985 through 1989 (Blodgett et al., 1990; Ikehara, 1994). Like spirit level transects, GPS monitoring of subsidence relies on periodic resurveying of a network of monuments. The accuracy of GPS surveys has gradually improved and is currently on the order of plus or minus 0.03 feet.

Ikehara (1994) estimated subsidence rates in the southern Sacramento Valley by comparing 1989 GPS survey data with historical data from spirit level transects. Although the accuracy of the 1989 survey (plus or minus 0.1 meter) was much less than more recent GPS surveys (Ikehara, 2004, pers. comm.), these are the best available data to estimate subsidence prior to 1989 at multiple locations. As shown on Figure 18, monuments with historical data in the vicinity of the Plan Area that were resurveyed in 1989 showed some subsidence. The only subsidence monument in the Plan Area is located near the Sacramento International Airport, where 1.9 feet of subsidence was reported between 1959 and 1989.

Land subsidence is also monitored at specific locations using borehole extensometers. Borehole extensometers are typically more accurate than GPS monitoring stations (detecting changes in land surface elevation to about 0.001 foot, or about 0.01 inch). The Sutter Extensometer, located at the northern tip of the Plan Area as shown on Figure 18, is the only borehole extensometer in the North American Subbasin. This extensometer is operated by DWR and is located adjacent to the DWR multiple-completion monitoring wells at 11N/04E-04N. The Sutter Extensometer is a pipe extensometer that measures compaction from the ground surface to its total depth of 780 feet.

The Sutter Extensometer began operation in April 1994, and Figure 19 shows the compaction/expansion data through February 2009. Also shown on Figure 19 are water levels for the deepest adjacent monitoring well (11N/04E-04N1), which is perforated from 880 to 890 feet. The compaction/expansion data show mostly elastic compaction that corresponds to seasonal and longer periodic fluctuations in groundwater levels. The cumulative land subsidence from Spring 1995 to Spring 2008 shown on Figure 19 is 0.013 foot, and the average rate of subsidence is 0.0019 foot per year.

Subsidence at the Sutter Extensometer has been relatively small as would be expected for the generally high and relatively stable groundwater levels at that location. Subsidence in the Plan Area would be expected to be small for the same reasons.

3.7 Areas of Concern/Identified Problems

In summary, groundwater conditions in the Plan Area indicate that groundwater levels are generally stable and historically high, with groundwater flowing to the south, east, and southeast. Groundwater levels fluctuate in the Plan Area according to season and climate. Groundwater on the east side of the Plan Area is drawn towards the groundwater depression located east of the Plan Area. Some localized groundwater quality issues that would be a potential concern for development and use for municipal and industrial supply include groundwater quality constituents that have exceeded secondary drinking water standards in the past: TDS, iron, manganese, and arsenic. Groundwater in the Plan Area is suitable for agriculture except for a small area to the west along the Sacramento River where boron concentrations have exceeded the agricultural water quality limit. Groundwater pumpage information in the Plan Area is limited, but it is clear that the maximum sustainable yield in the area has not yet been reached, indicating the potential to increase groundwater development with ongoing integration of surface water use. Subsidence is not an issue in the Plan Area, as extensometer data and water levels have shown minimal recent subsidence, most of which is elastic.

Connection Between the Sacramento River and Aquifer

Concerns have been expressed that development of groundwater in the Natomas area could induce inflow from the Sacramento River, thereby intercepting Central Valley Project (CVP) or State Water Project water. The nature and extent of the hydraulic relationship between the Sacramento River and the local aquifer system beneath Natomas are not fully understood, but are critical to an effective integration of groundwater as a component of overall water supply to the local area. Components of this plan will assist in investigation and definition of this relationship, including how it might impact the planned conjunctive use of surface and groundwater. Selected wells will be specifically tested and/or monitored during groundwater extraction to evaluate groundwater level response to the pumping, to determine the hydraulic characteristics of the aquifer materials, and to assess stream-aquifer connection (or disconnection) between the aquifer system and the river.

Local and Regional Overdraft Conditions

While no overdraft conditions have been identified in the Plan Area, extensive historical use of groundwater to the east of the Plan Area has resulted in a pumping depression which influences water levels in the eastern portion of the Plan Area. This depression has developed over the last 60 years and remains the direct focus of regional water supply planning and management by SGA. NCMWC anticipates the opportunity to cooperate in the regional solution with other water purveyors outside of its service area. Current independent planning is proceeding toward stabilization of groundwater conditions to the east, including possible groundwater banking in the existing depression to make beneficial use of the vacated aquifer storage space. Increased conjunctive use operations in the Plan Area could contribute toward the local and regional water supplies, but will also have to recognize the constraints associated with the historically developed depression immediately to the east. Cooperation, and integration where possible, with SGA's developing groundwater management program is expected to optimize water supply opportunities in Natomas while also benefitting the solution to depressed groundwater levels to the east.

Groundwater Quality: Near River and McClellan Air Force Base

Areas of poor quality groundwater have been identified in the western and southern portion of the Plan Area, with maximum sampled concentrations of arsenic, sodium, iron, and manganese that exceed agricultural or drinking water standards. In addition, groundwater impacted by organic chemicals occurs in the vicinity of McClellan Air Force Base immediately east of the Plan Area. Modification of groundwater gradients, locally or on a more regional basis, could potentially impact groundwater quality in areas beyond those currently experiencing water quality impairment, and thus potentially constrain conjunctive use operations within Natomas. The development and implementation of a conjunctive use program in the Natomas area will be designed to address potential water quality constraints or issues.

Residential and Industrial Development within and east of the Plan Area

Increasing domestic water demands caused by residential and industrial development, within and also east of the Plan Area is a concern of NCMWC. Within the Plan Area, an additional 60,000 residents, airport expansion to service upwards of 8,000,000 travelers annually, addition of commercial and destination businesses on thousands of acres adjacent to the airport, and possible addition of other commercial enterprises in the northeast section of the service area will dramatically alter local and regional water demands. This Plan's management objectives intend to protect the groundwater resource from adverse impacts.

4. Components of the Natomas Area Groundwater Management Plan

To pursue the groundwater management objectives for the area, and to address the identified concerns in and near the Plan Area, this Natomas Area Groundwater Management Plan has been developed to provide a framework for present and future actions. It is expected that this plan will be updated as new data are developed, particularly in light of the key role that groundwater monitoring (water levels and quality) will continue to play in defining groundwater conditions and aquifer response to management actions.

As introduced above, the management objectives for the Natomas area include the following:

Goal 1: Development of Local Groundwater for Water Supply
Goal 2: Avoidance of Overdraft and Associated Undesirable Effects
Goal 3: Preservation of Groundwater Quality
Goal 4: Preservation of Interrelated Surface Water Resources

With the intent to be consistent with the opportunities provided by local agency management of groundwater resources, this plan identifies a total of ten plan elements which are collectively intended to accomplish the management objectives for the area. To a certain extent, the plan elements restate, or expand, certain plan goals to include additional activity (e.g. development and conjunctive use of surface water and groundwater), and the necessary wider focus of local groundwater management planning (e.g. cooperation with adjacent water purveyors and state and federal agencies) to address the growing need for regional resource planning. In summary, the Natomas Groundwater Management Plan is intended to enable Natomas to continue use of local surface water diversions, with expanded use of local groundwater, for agricultural and other water supply and to work with other agencies via implementation of the following management plan elements.

Element 1: Monitoring of Groundwater Levels and Quality
Element 2: Monitoring of Surface Water Flows and Quality
Element 3: Determination of Groundwater Yield and Avoidance of Overdraft
Element 4: Groundwater Development for Expanded Conjunctive Use and Groundwater Substitution Transfer Programs
Element 5: Avoidance of Groundwater Quality Degradation
Element 6: Development and Continuation of Federal, State, and Local Agency Relationships

Element 7: Continuation of Public Education and Water Conservation Programs
Element 8: Well Construction, Abandonment & Destruction Policies
Element 9: Management and Protection of Recharge Areas and Wellhead Protection Areas
- water quality protection
- manage vertical distribution of pumpage and control of river impacts

Element 10: Provisions to Update the Groundwater Management Plan

Element 1 – Groundwater Monitoring

Historically, the primary mission of the NCMWC has been to divert and deliver surface water for irrigation of lands within its service area. As a result, groundwater has not been a major water supply component (except in those parts of NCMWC where surface waters cannot be easily delivered) and thus has not been monitored and interpreted on a regular, ongoing basis. However, because this Plan includes groundwater development for expanded conjunctive use and potential groundwater substitution transfers, groundwater monitoring will become more important. Historically, the State Department of Water Resources has maintained a database of groundwater level measurements on over 100 wells within the Natomas area, many of which have records that date back to the 1950's and 1960's. In addition to general groundwater level measurements and some groundwater quality monitoring, it is expected that focused monitoring of stream-aquifer conditions, possibly through the installation of dedicated monitoring wells, will be important to both conjunctive use operations and potential water transfer operations. Focused monitoring will also be essential to address potential issues with private or other (third-party) well owners. Thus, this element will focus on the design and implementation of a program to monitor and regularly interpret groundwater levels, quality, flow directions, stream impacts, and pumping impacts of conjunctive use and potential groundwater substitution, or other water transfer, operations. This element will also focus on the development of a database, or possibly on the integration of Natomas' data into the database developed as part of SGA's groundwater management program, for storage and ready access to various data for ongoing analysis and interpretation of groundwater basin conditions. This Groundwater Monitoring Element is essential to accomplishment of all four management objectives (goals) for the area.

Element 2 – Surface Water Monitoring

Surface water diversions from the Sacramento River are measured at NCMWC's five river diversion sites by NCMWC and the U.S. Bureau of Reclamation. Because of the service area's flat topography, NCMWC operates 84 internal pumps at 35 locations to recirculate drain water and sixteen pumping stations to re-use it. NCMWC operates a modified/quasi "closed" system, i.e., minimal return flow (tailwater) is discharged back into the Sacramento River from April through the end of the rice irrigation season. Because of its extensive recovery and re-use of agricultural drainage, NCMWC will continue to explore additional opportunities for internal measurement, if such on-farm measurements prove to be supportive of increased beneficial use.

Since surface water is such a substantial component of water supply in the Natomas area, this component will focus on the design and implementation of a program to monitor and regularly interpret surface water diversion, quality, and recirculation. As with groundwater monitoring, this element will also focus on the development of a database, or possibly the integration into SGA's database, for storage and ready access to various surface water data for ongoing analysis and interpretation of surface water-related aspects of overall water resources in the Natomas area. This Surface Water Monitoring Element is primarily essential to accomplishment of the fourth of the goals for the area.

Element 3 – Determination of Groundwater Yield and Avoidance of Overdraft

On a long term basis, there have historically been relatively high and stable groundwater levels, and no widespread, steady decline in groundwater levels throughout most of the Natomas area. While there have been short-term fluctuations, e.g. during periods of drought when groundwater levels have been drawn down, followed by recovery in subsequent wet years, there has been no area-wide trend toward groundwater decline that might be indicative of overdraft. The local exception to this is in the east and southeast parts of the Plan Area, where the North County pumping depression has influenced groundwater levels into the Natomas area, resulting in a downward trend of several tens of feet over the last 30 to 45 years. Management of that depression is a policy target of SGA.

As data are collected during the conjunctive use and water transfer activities outlined in this Plan, aquifer response to different amounts of groundwater extraction within the Plan Area, through wet and dry cycles will be monitored and analyzed. This is expected to provide the level of detail necessary to initially empirically estimate, and ultimately identify the long-term yield of the aquifer system beneath the Plan Area, and better define the constraints and opportunities for fully developing local groundwater resources. Initial empirical estimates of yield may be complemented through the development and application of a numerical groundwater flow model of the Plan Area. A better understanding of aquifer storage characteristics and stored water recovery will also be obtained. The ultimate intent of this Plan Element is to develop an understanding and quantification of the yield of that part of the basin underlying Natomas, under varying hydrologic conditions and changing local cultural conditions, so that groundwater development and use can be conjunctively managed with surface water supplies to meet appropriate fractions of total water demand while avoiding groundwater pumping rates that would result in overdraft conditions, e.g. declining groundwater levels, migration of poor quality groundwater, land subsidence, etc. Thus, implementation of this Plan Element is essential to accomplishing the second management objective (goal) for the area.

Element 4 – Groundwater Development for Expanded Conjunctive Use and Groundwater Substitution Transfer Programs

NCMWC's own conjunctive use program would involve the development of additional groundwater as a complement to historic surface water supplies, in part to be able to fulfill its commitment of up to 15,000 af as part of the Phase 8 Settlement Agreement by reducing surface water diversions in certain years (and thus make possible the potential transfer of some surface water entitlements), and in part to improve the yield and quality of the aquifer system in North Sacramento County in cooperation with SGA. Pursuit of such conjunctive use programs would be designed to provide technical data, via well and aquifer testing as well as focused groundwater monitoring, that are essential to addressing (including mitigation as necessary) the questions of river-aquifer interaction and third-party impacts, i.e., impacts of pumping Natomas or other "program" wells (as part of planned conjunctive use or groundwater substitution water transfer programs) on nearby non-program wells in order that any adverse impacts be avoided or mitigated.

NCMWC will also continue to evaluate the potential for participation in the DWR-sponsored American Basin Conjunctive Use Project to improve supplies. In addition, NCMWC will continue to investigate other conjunctive use operations, primarily in cooperation with SGA and the American River Basin Cooperating Agencies (ARBCA), and groundwater substitution transfer programs. The DWR American Basin conjunctive use program would involve substantial groundwater extraction during dry and critically dry years to replace reduced river diversions during those periods. Subsequent delivery of State Water Project water, and corresponding reduction of groundwater pumping during wet and above normal years, would then be expected to recharge the aquifer system via a combination of deep percolation of applied irrigation water and other prevailing recharge mechanisms.

Implementation of an integrated conjunctive use program will require construction and operation of extraction facilities (wells and pumps), conveyance facilities, and possibly artificial recharge facilities. These facilities have not yet been identified and will require further evaluation and design before locations, types, and number of facilities can be formulated. Such facilities will also need coordination with the installation of new diversions for surface water as well as the need for regional facilities for both surface and groundwater conjunctive use.

Groundwater substitution transfers, involving reduced surface water deliveries and increased groundwater pumping during a transfer period, may also be pursued by NCMWC. The goal of a groundwater substitution water transfer would be to provide other areas with water for beneficial use during dry periods when normal supplies might be reduced in those areas. While there could also be other water transfer efforts involving land fallowing or changed cropping patterns, in this case groundwater would substitute for reduced surface water diversions. Monitoring and mitigation plans would be prepared in order to participate in such a transfer, notably to address the kinds of river-aquifer interconnection and third-party impact issues noted above.

Overall, implementation of this Plan Element is essential to accomplishment of all four of the management objective (goals) for the Plan Area.

Element 5 – Avoidance of Groundwater Quality Degradation

Groundwater quality is suitable for domestic, industrial, and agricultural purposes in the majority of the Plan Area. Limited available water quality data indicates that groundwater in the west to southwest part of the Plan Area has concentrations of some water quality constituents that exceed agricultural and/or drinking water standards. Similarly, limited data suggest that there are stratigraphic differences in concentrations of various individual groundwater quality constituents. By expanding groundwater quality monitoring (Element 1) and managing the groundwater pumping component of a conjunctive use operation, and thus managing groundwater levels and the resultant hydraulic gradients for flow (and associated mobilization of groundwater quality constituents), this Plan is intended to better define groundwater quality and to control or avoid any undesirable movement of poorer quality groundwater, and to thus meet any water quality objectives as part of full implementation of a local or regional conjunctive use or water transfer program. This is basically intended to be accomplished through implementation of this Plan Element in coordination with Elements 4 and 8 to site wells and develop groundwater through well locations and well completions that will achieve acceptable groundwater quality and avoid development of local or other gradients that could induce movement of known poorer quality groundwater.

This Plan includes intended participation in land use planning in the Plan Area. This participation will provide opportunities to review and comment on planned land use, particularly when changing from agricultural land use, that could potentially impact groundwater recharge and/or groundwater quality. NCMWC is a participant in local planning decisions, as land use change may affect water supply for the area.

Implementation of this Plan Element is essential to accomplishment of the third management objective (goal) for the area.

Element 6 – Development and Continuation of Federal, State, and Local Agency Relationships

NCMWC has a working relationship with the Sacramento Groundwater Authority (SGA) toward cooperative management of water resources for the mutual benefit of both entities. SGA's

Groundwater Management Plan (December, 2008), includes five component categories: 1) Stakeholder Involvement, which involves public and other agencies, including state and federal agencies encouraging partnership opportunities; 2) Monitoring Program, which includes monitoring and collection of groundwater elevation and quality, land subsidence, and surface water-groundwater interaction monitoring data; 3) Data Management and Analysis, based on data storage in a Data Management System (DMS); 4) Groundwater Resource Protection, which involves both prevention of contamination from entering groundwater and remediation of existing contamination; and 5) Groundwater Sustainability, which involves conjunctive management activities such as in-lieu recharge and demand reduction by water conservation and recycling efforts. The SGA Plan also emphasizes Plan Integration by identifying the need to integrate water management planning on a regional scale for long-term sustainability of the region's groundwater resources. Given the common components and complementary goals of the SGA and Natomas groundwater management plans, NCMWC will continue to cooperate and complement groundwater and overall water resource management regionally.

NCMWC has a working relationship with the Department of Water Resources in monitoring groundwater conditions in the area. It is also involved with the Department in DWR's ongoing study of potential conjunctive use of surface and groundwater in the greater American Basin, and it intends to continue to work on this program in cooperation with the Department. On a short-term basis, while NCMWC was not physically prepared to pump and distribute additional groundwater in order to participate in the State's 2009 Drought Water Bank, it is envisioned that, through implementation of this Plan, notably Elements 3, 4 and 8, NCMWC will be positioned to participate in future Drought Water Banks or other comparable transfer programs through groundwater substitution.

NCMWC also worked with the Bureau of Reclamation and DWR in writing and planning the 2003 Sacramento River Basin Wide Water Management Plan. This study was conducted along with thirteen other Settlement Contractors in the Sacramento River Basin and considered the effective use of groundwater and conjunctive use programs for the first time in the history of such relationships between the Bureau and Sacramento River diverters. On a shorter-term basis, NCMWC proposed and negotiated with the Bureau for a potential short-term transfer of water during the 2000 irrigation season, on a demonstration and test basis, i.e., to demonstrate that in-lieu recharge can replace pumped groundwater, to test the pumped wells, and to monitor selected other wells to describe and quantify the river-aquifer interconnection, or lack thereof. However, since the Bureau did not have a need for the water in the 2000 irrigation season, NCMWC will continue to seek the Bureau's participation in such a demonstration and test in the future.

Additionally, NCMWC has a working relationship with the Department of National Marine Fisheries, U.S. Fish and Wildlife Service in the planning, design, and installation of a new river diversion which is expected to provide extensive benefits to fisheries. This project is linked to the planning for conjunctive use and the integrated use of groundwater with surface water diverted via the new river facilities. Consequently these agencies will be included in the consultation about the groundwater management plan as it applies to their public policy positions on natural resources.

Locally, NCMWC and the Natomas Basin Conservancy (NBC) have an interactive agreement whereby NCMWC can deliver surface water to the NBC and can call on groundwater from NBC wells when not needed for water supply on NBC lands. The latter groundwater pricing includes an incentive whereby NCMWC pays for actual power consumption plus a fraction to contribute to maintenance of NBC groundwater facilities.

Finally, while this Plan does not include regular formal reporting on the groundwater basin, it is intended to reflect an intention to share data and other aspects of groundwater management with the appropriate Federal, State, County (Sutter and Sacramento), and other pertinent agencies and organizations.

Implementation of this Plan Element is essential to accomplishment of all four management objectives (goals) for the Plan Area.

Element 7 – Continuation of Public Education and Water Conservation Programs

As part of the Sacramento River Basin Wide Management Plan, NCMWC is committed to the creation of criteria for regional conservation programs. Such a regional approach has been approved by Federal agencies, and is consistent with the goals of CVPIA. Within that Plan, the area from Shasta to Sacramento is divided into distinct sub-basins with particular, sometimes unique, hydrologic characteristics. NCMWC is in a subbasin defined as the North American Subbasin, an area larger than the boundaries of this Plan and inclusive of some local purveyors within SGA. When the regional criteria are completed, an extensive education/outreach program, already underway, will involve all political subdivisions from Shasta County to Sacramento County, all water rights holders within each subbasin, and all Federal and State natural resource agencies. This NCMWC Groundwater Management Plan is intended to be included in the larger Basin Wide Water Management Plan. Specifically, this particular plan will be submitted to SGA, ARBCA, the *Water Forums* and State and Federal agencies for integration with other local and subregional planning. Meetings to facilitate an understanding of the plan will formally begin the process. Implementation of this Plan Element is essential to accomplishment of the second management objective (goal) for the Plan Area.

Element 8 – Well Construction, Abandonment, and Destruction Policies

Historically, no problems have been identified in the Plan Area requiring special well construction, abandonment, or destruction policies. NCMWC accepts the minimum standards set forth in Water Code Sections 13700 through 13806. These standards are expected to continue to be administered through the local County permitting processes. Depending on findings related to other elements of this overall Plan, most notably with regard to River-aquifer interconnection and/or groundwater quality, there may become a need to site-specifically augment well construction or destruction standards (e.g., well location, well depth, location of intake section, seal depths, etc.) to selectively produce water of a certain quality or to control or mitigate pumping impacts on surface water or on the movement of groundwater quality constituents. Depending on the importance of such considerations, this Plan will be expanded to incorporate them as appropriate. Implementation of this Plan Element is essential to accomplishment of all four of the management objectives (goals) for the Plan Area.

Element 9 – Management and Protection of Recharge Areas and Wellhead Protection Areas

Aquifers beneath the Plan Area are recharged by precipitation, streamflow, applied irrigation water, and subsurface inflow from other areas. While land use in the area has historically been primarily agricultural, expanding municipal and industrial land uses represent potential new impacts to the quality of the local groundwater supply. Groundwater management activities will continue to monitor land use impacts on groundwater recharge, and will potentially lead to participation in land use planning to protect critical recharge areas.

Similarly, wellhead protection areas within which pumping of individual wells directly affects groundwater flow towards those wells will be analyzed and mapped with the intent to protect them from potentially adverse overlying land use. This is expected to gain increasing importance as local groundwater use evolves to become a component of increasing municipal water supply.

Implementation of this Plan Element is essential to accomplishment of the first three management objectives (goals) for the Plan Area.

Element 10 – Provisions to Update the Groundwater Management Plan

The elements of this local area Groundwater Management Plan reflect the current understanding of the occurrence of groundwater in the Natomas area, and the specific problems or areas of concern about that resource. The management components are designed to achieve certain goals to protect and preserve groundwater quantity and quality for overlying beneficial use into the foreseeable future, as land use and related water requirements are projected to change from predominately agricultural to significantly municipal and industrial. At the same time, the management components of this plan are intended to create an opportunity for development of additional local groundwater, and to conjunctively utilize it with the historical surface water supplies available to the area via water rights and contracts. The planned conjunctive use of surface and groundwater is also intended to create opportunities for transfer of surplus water, either locally or otherwise, to contribute toward solution of nearby or other water supply problems. However, it is also recognized that, while the Groundwater Management Plan provides a framework for present and future actions, new data will be developed as a result of implementing the Plan. That new data could define conditions which will require modifications to currently definable management actions. As a result, this Plan is intended to be a flexible document which can be updated to modify existing components and/or incorporate new components as appropriate in order to recognize and respond to future groundwater conditions and to address changing management objectives as they evolve in the Plan Area.

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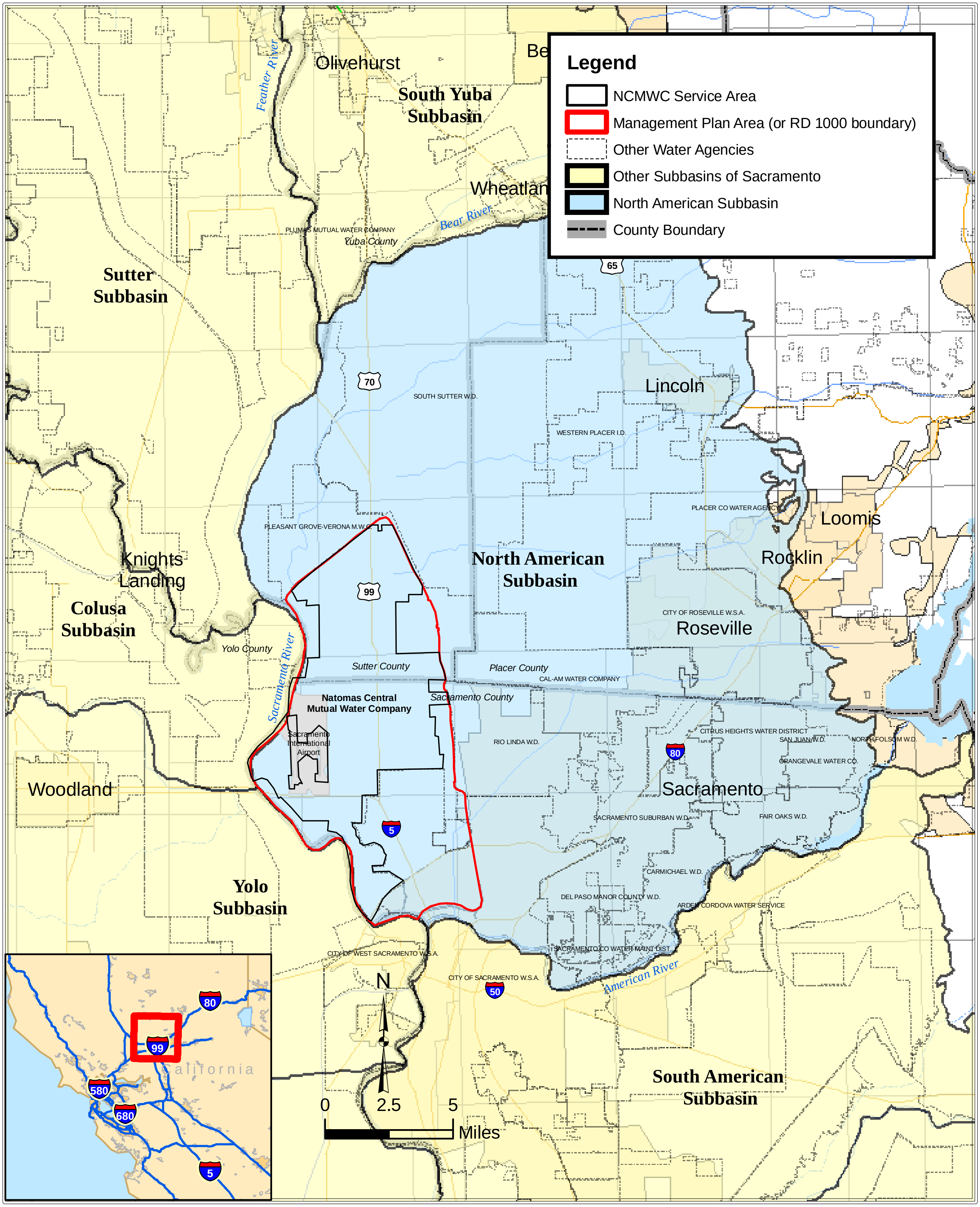

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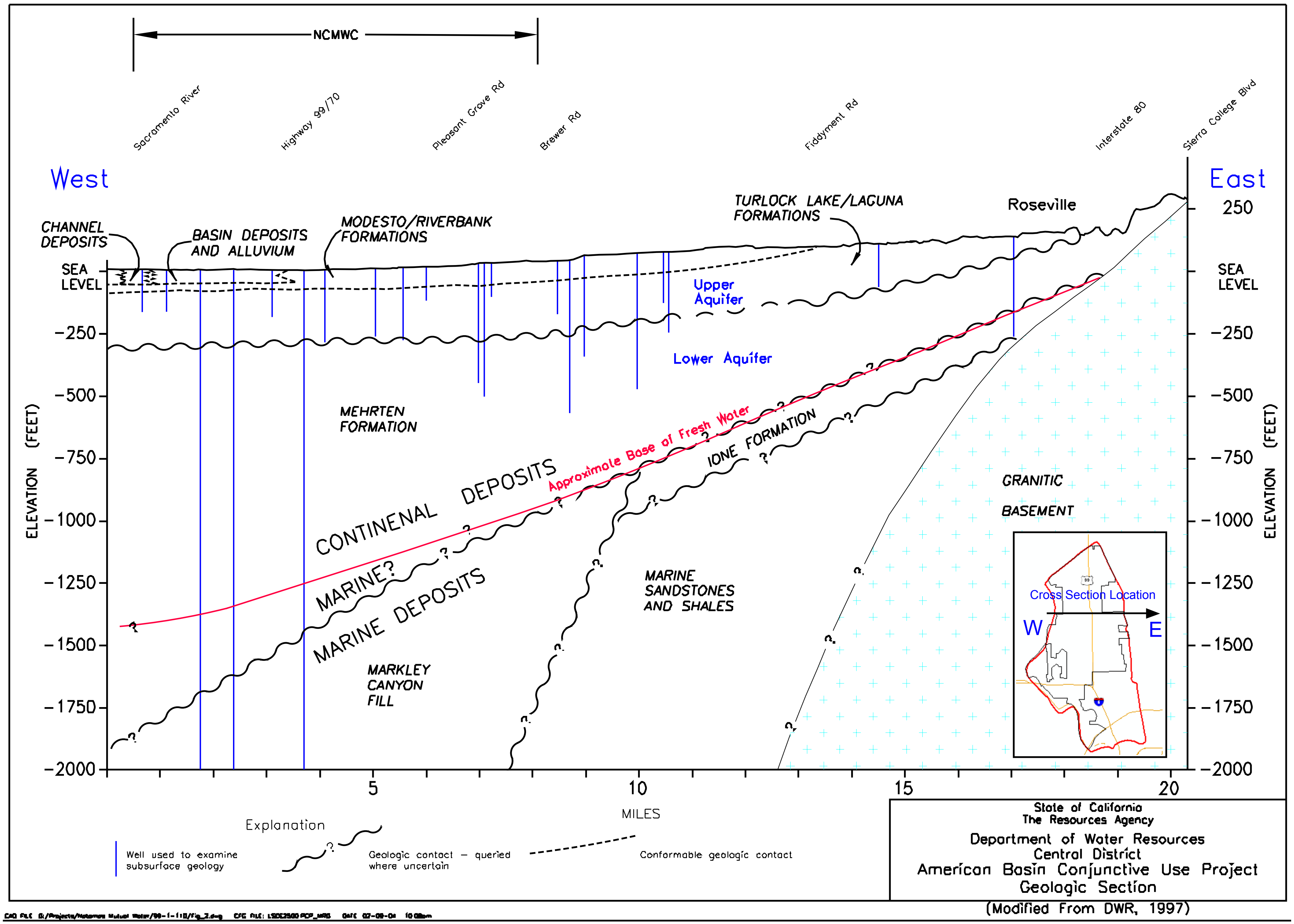
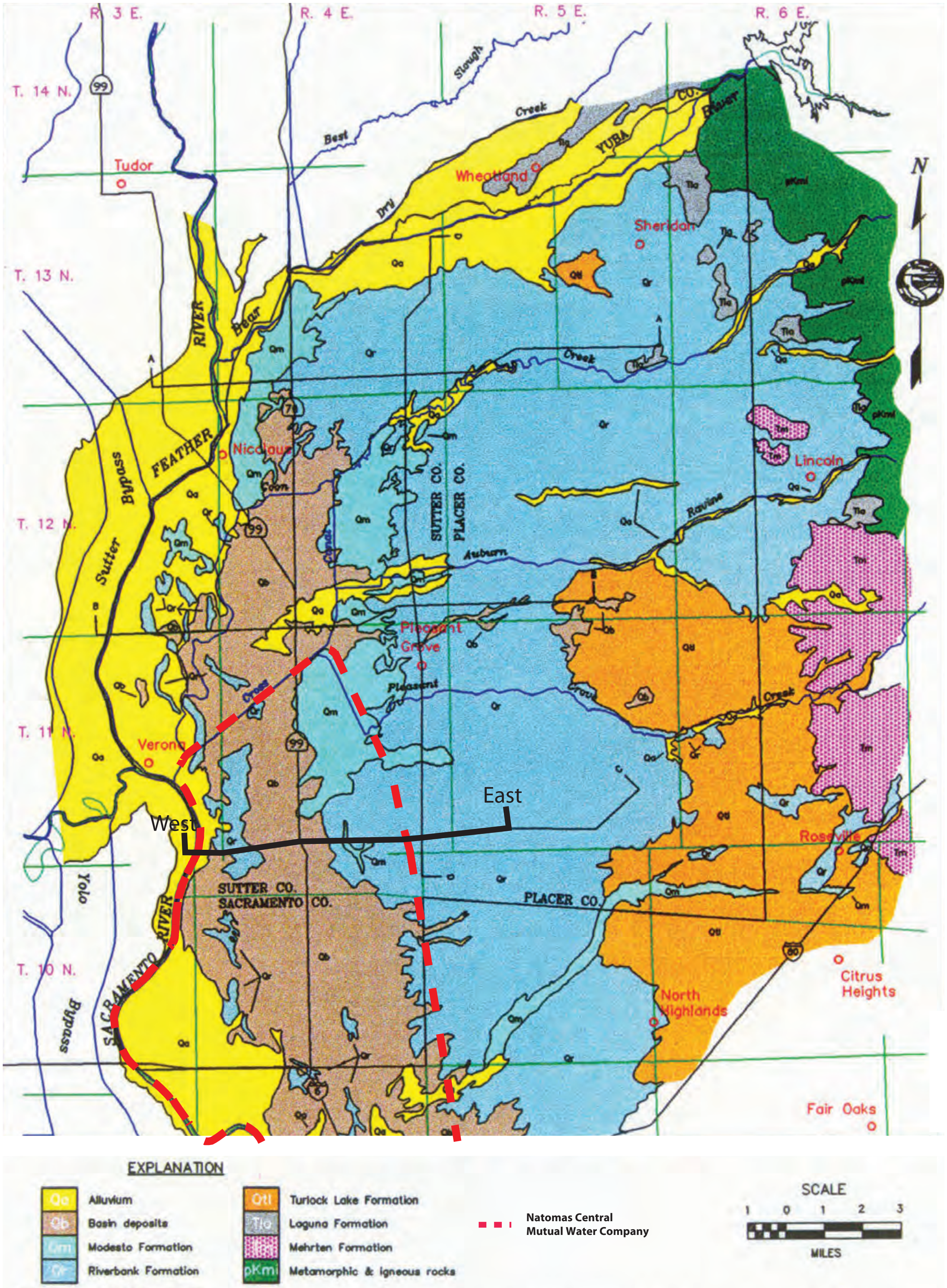
Figure 1
Location Map - Natomas Central MWC
North American Subbasin
Sacramento Valley Groundwater Basin



NATOMAS CENTRAL MUTUAL WATER COMPANY

Figure 2
General Geologic Section
Northern Natomas Central MWC Area



adapted from DWR, 1997 Feasibility Report, American Basin Conjunctive Use Project

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Figure 3
Generalized Geologic Map with Cross-Section Location
North American Subbasin

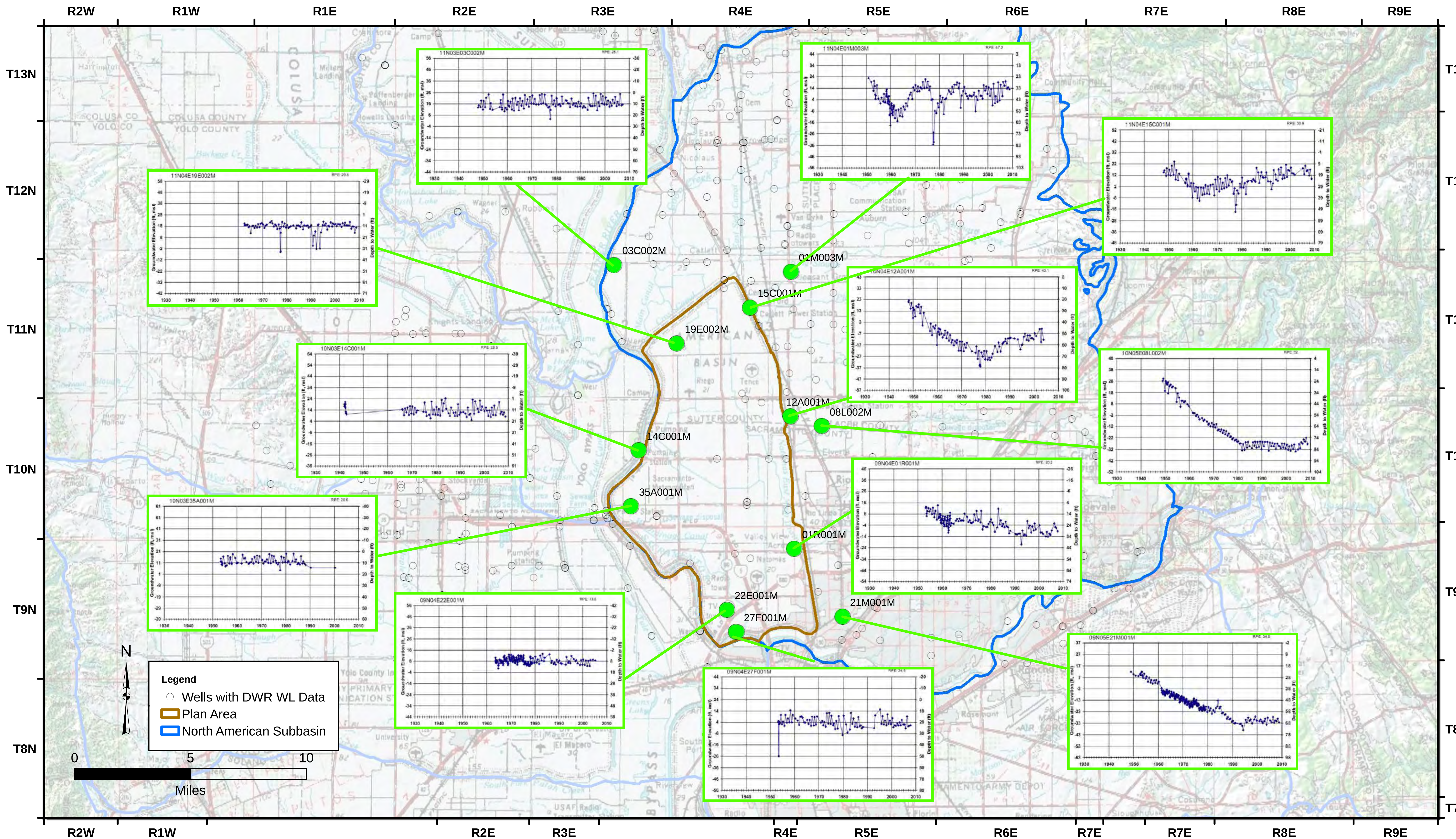

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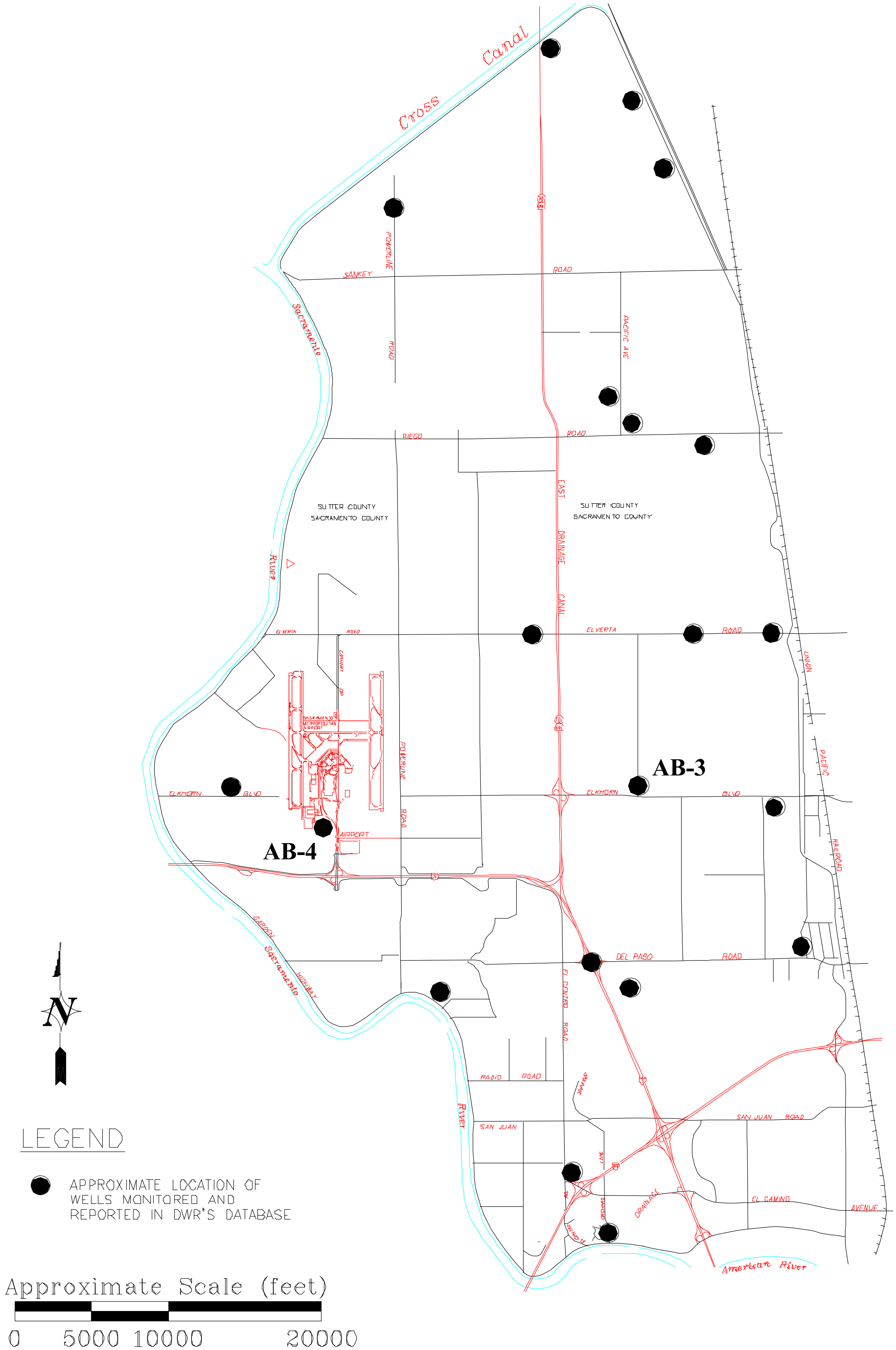
Figure 4
Natomas Central Mutual Water Company
Selected Hydrographs and
Wells with Water Level Data



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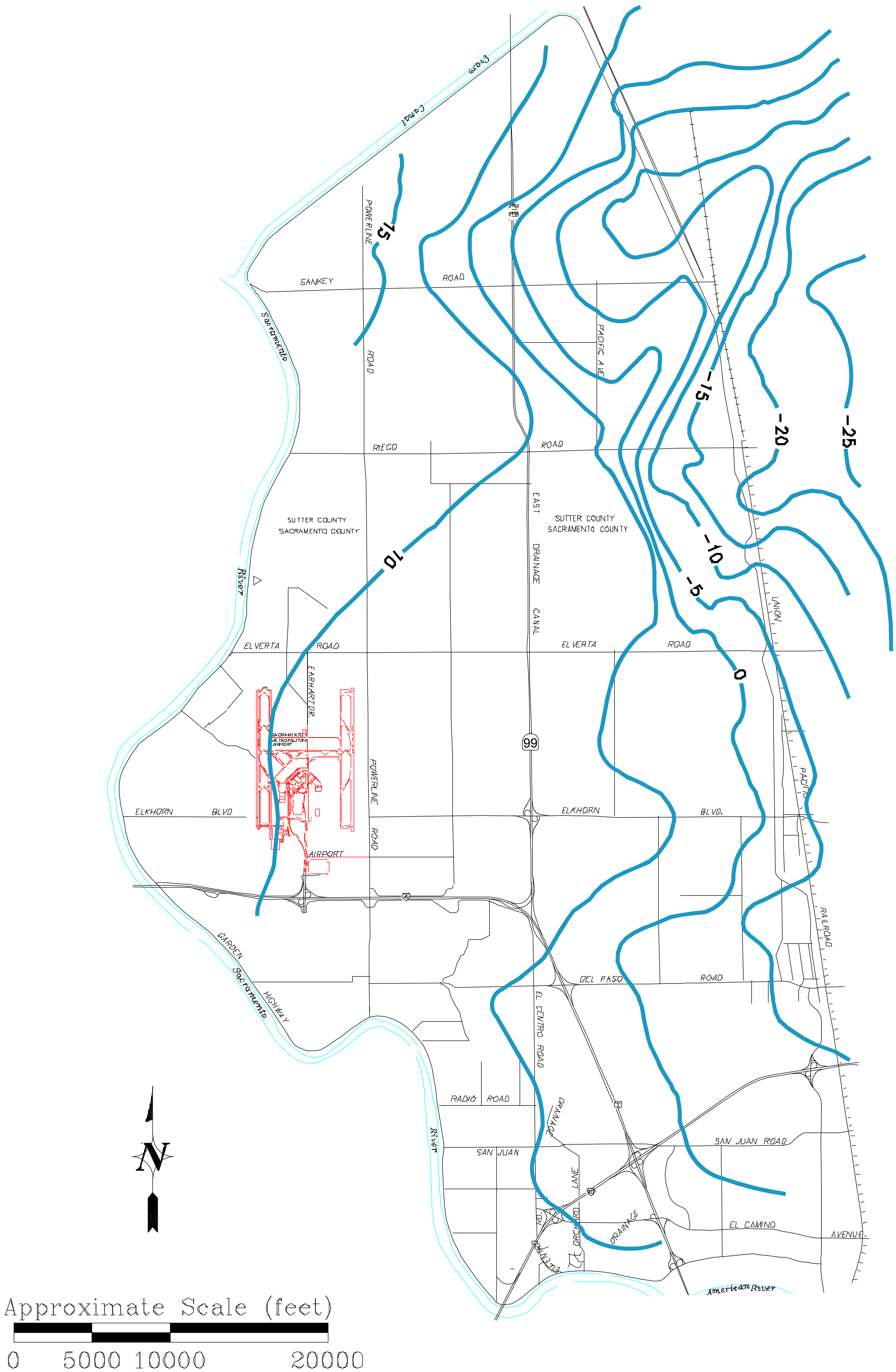
NATOMAS CENTRAL MUTUAL WATER COMPANY

Figure 5
Monitored Wells in the Management Plan Area



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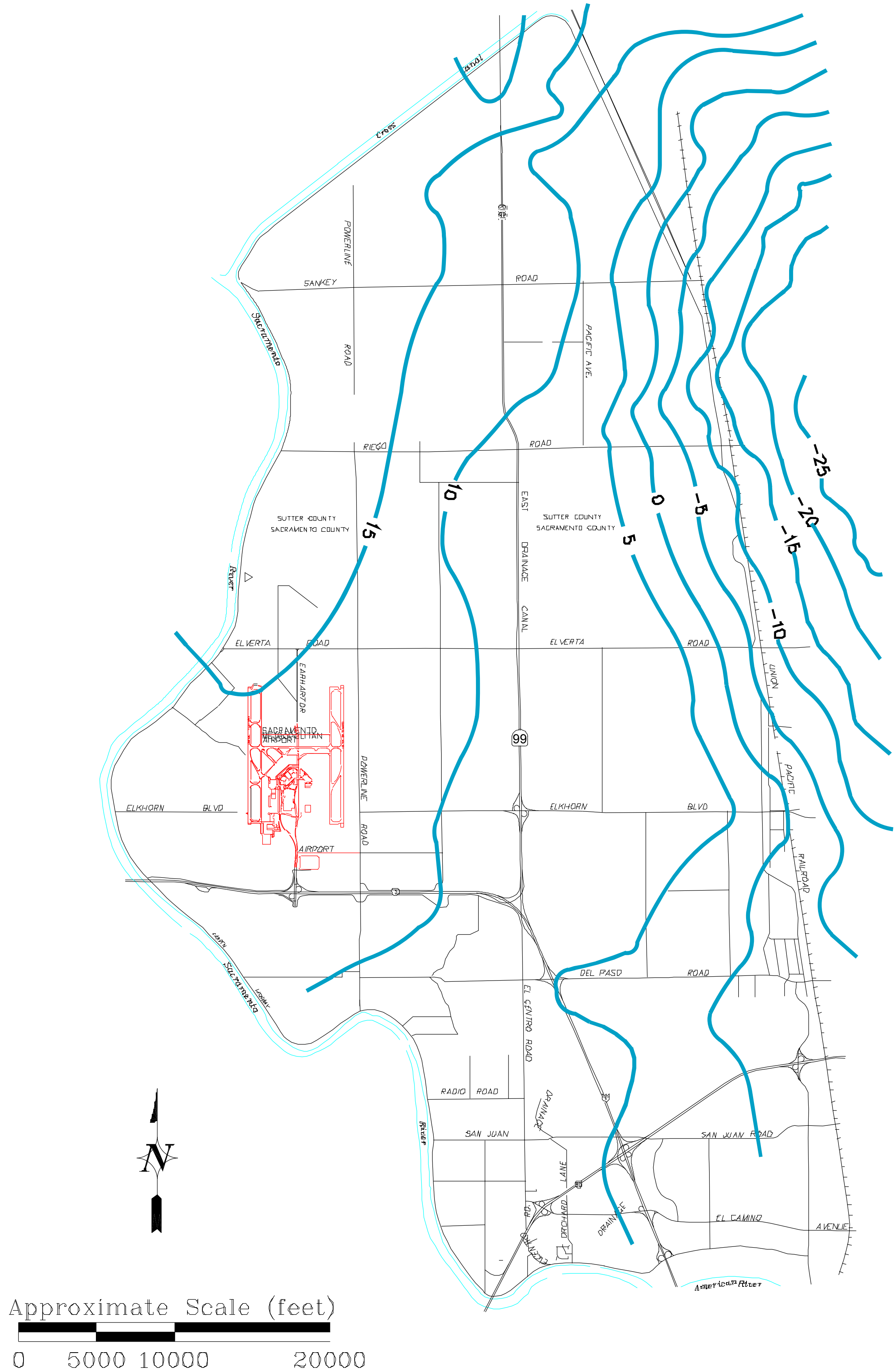
NATOMAS CENTRAL MUTUAL WATER COMPANY

Figure 6
Contours of Equal Groundwater Elevation
Spring 1977



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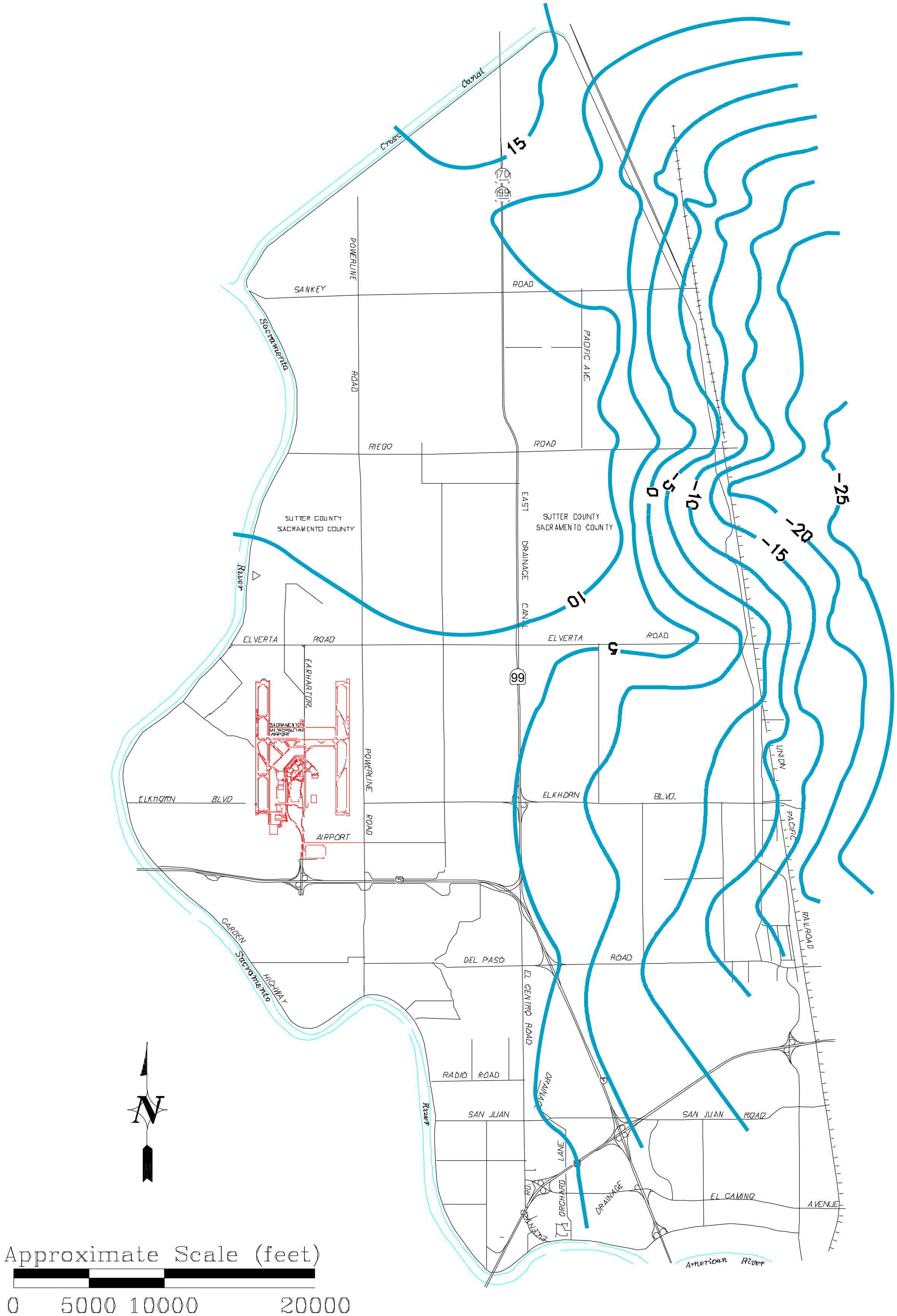
NATOMAS CENTRAL MUTUAL WATER COMPANY

Figure 7
Contours of Equal Groundwater Elevation
Spring 1984



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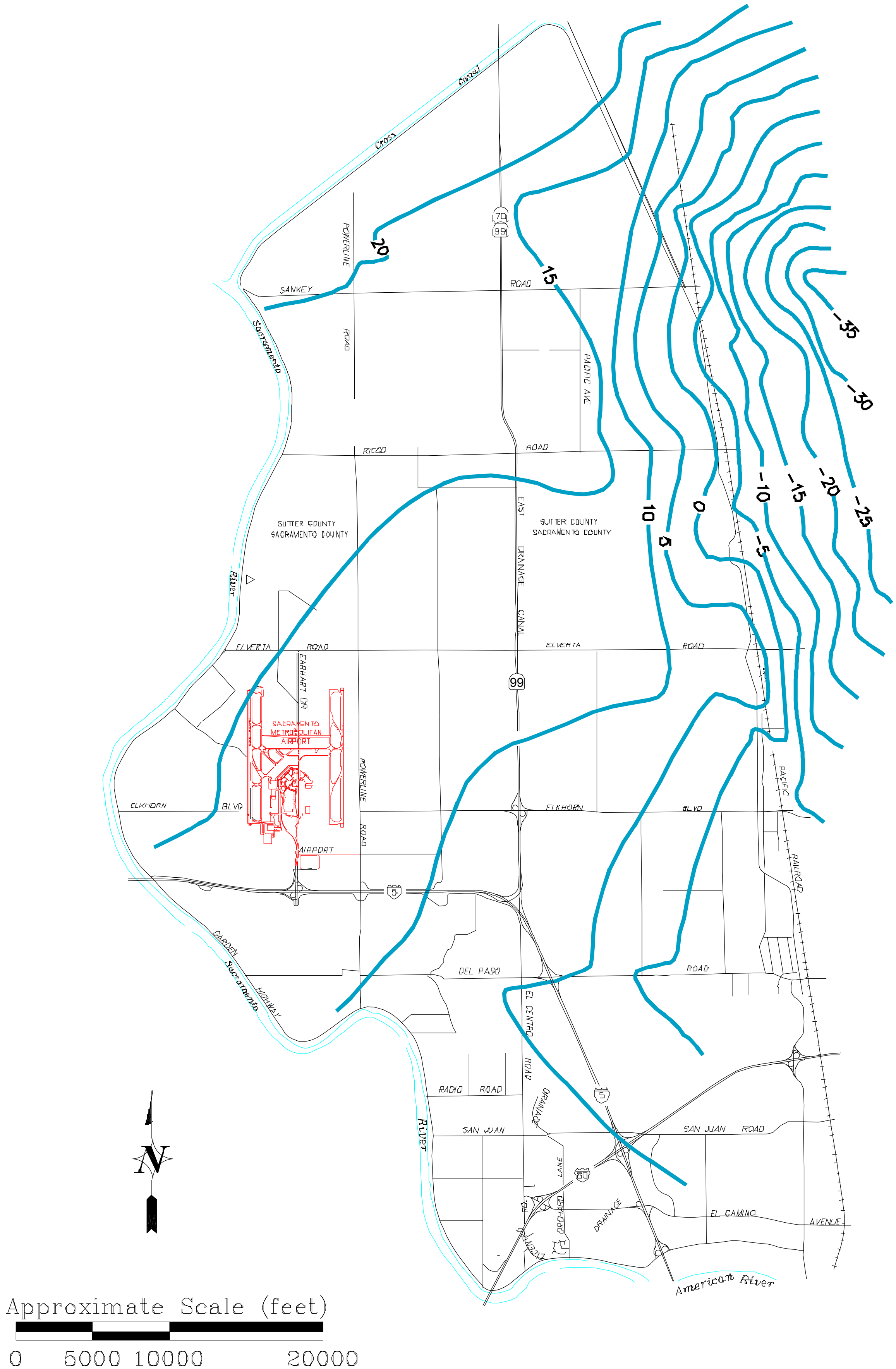
NATOMAS CENTRAL MUTUAL WATER COMPANY

Figure 8
Contours of Equal Groundwater Elevation
Spring 1994



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NATOMAS CENTRAL MUTUAL WATER COMPANY

Figure 9
Contours of Equal Groundwater Elevation
Spring 1996

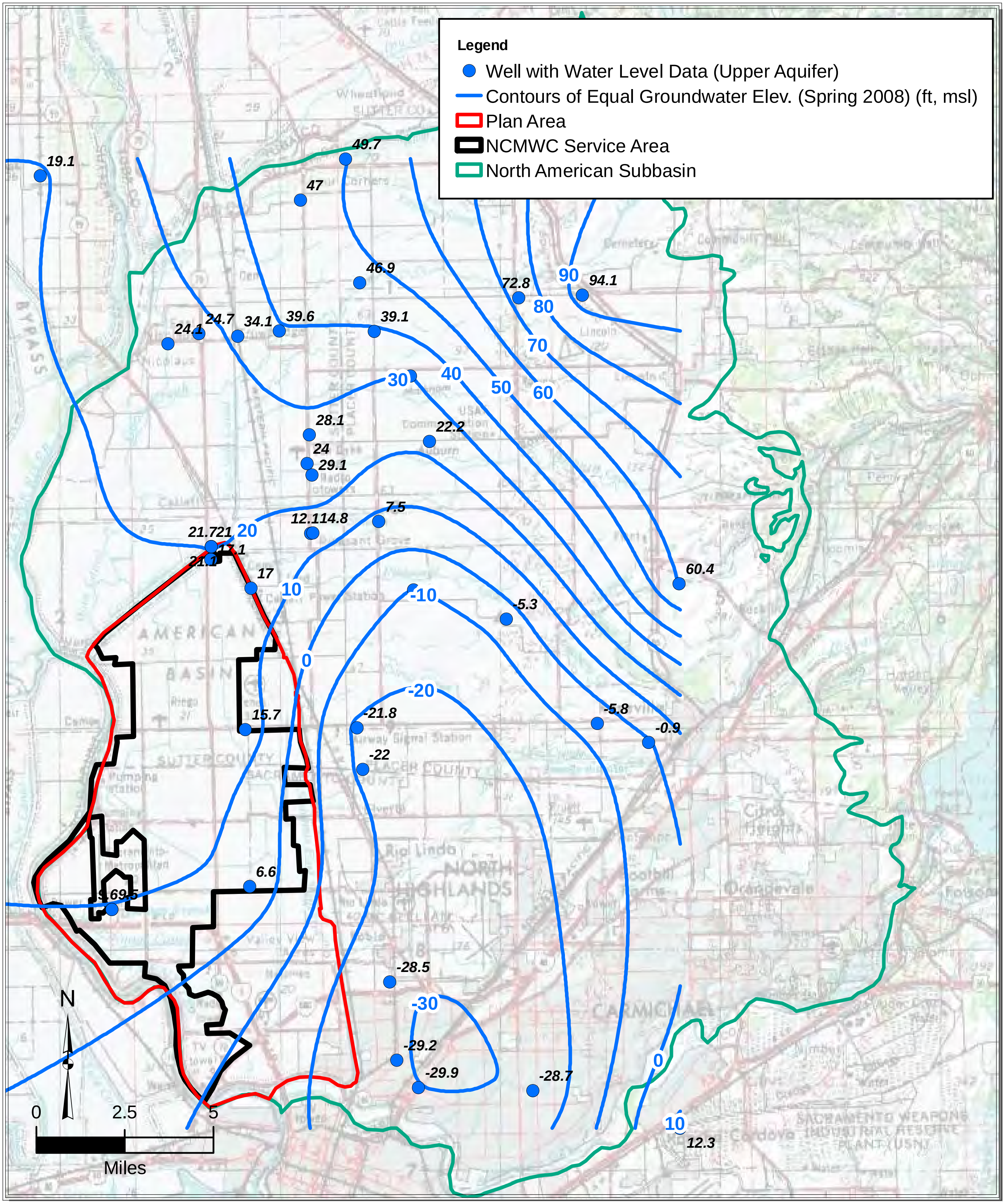

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Figure 10
Contours of Equal Groundwater Elevation
North American Subbasin (Spring 2008, Upper Aquifer)

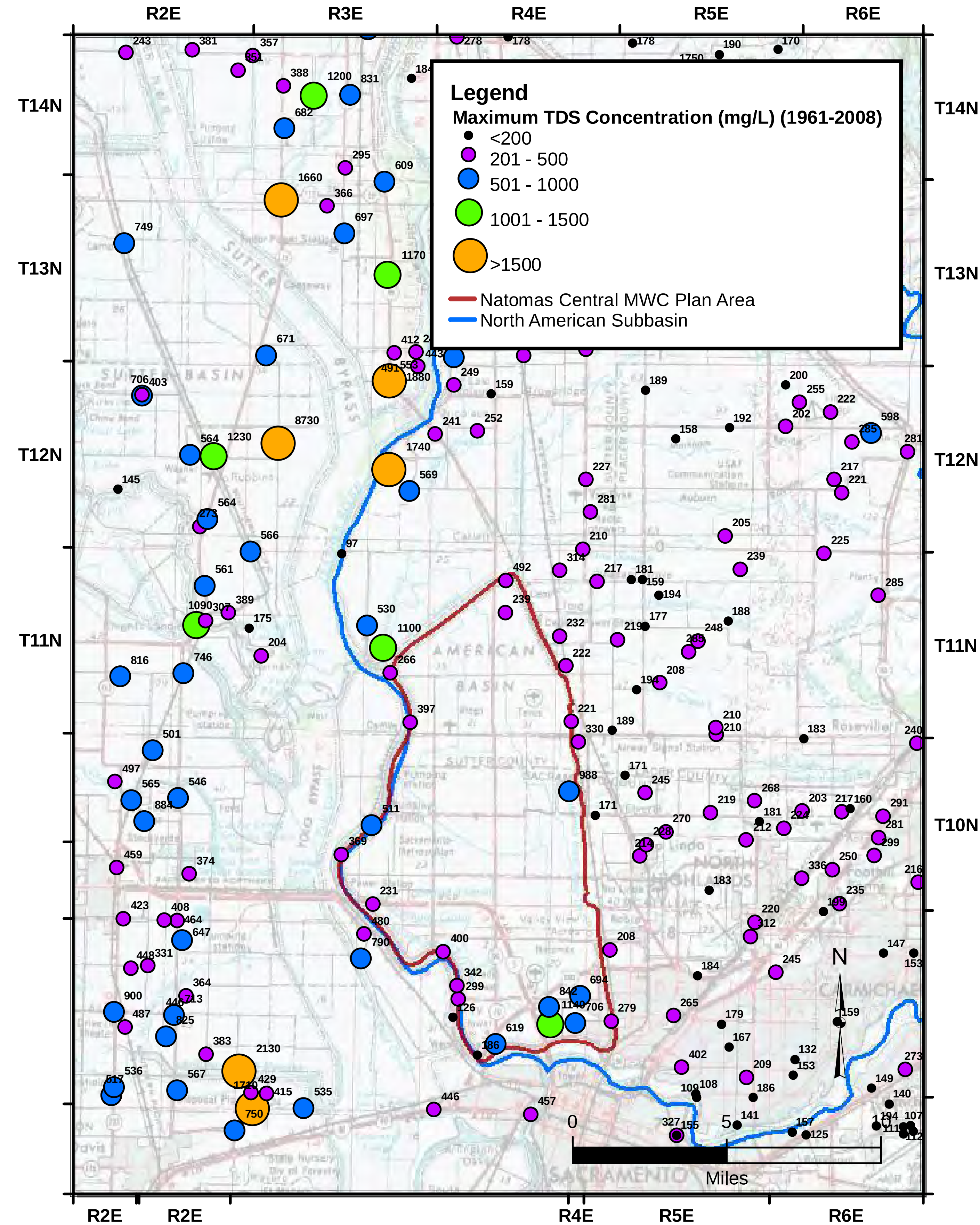

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Figure 11
Maximum Total Dissolved Solids (TDS) Concentration for Wells In and Near the Plan Area, 1961 to 2008

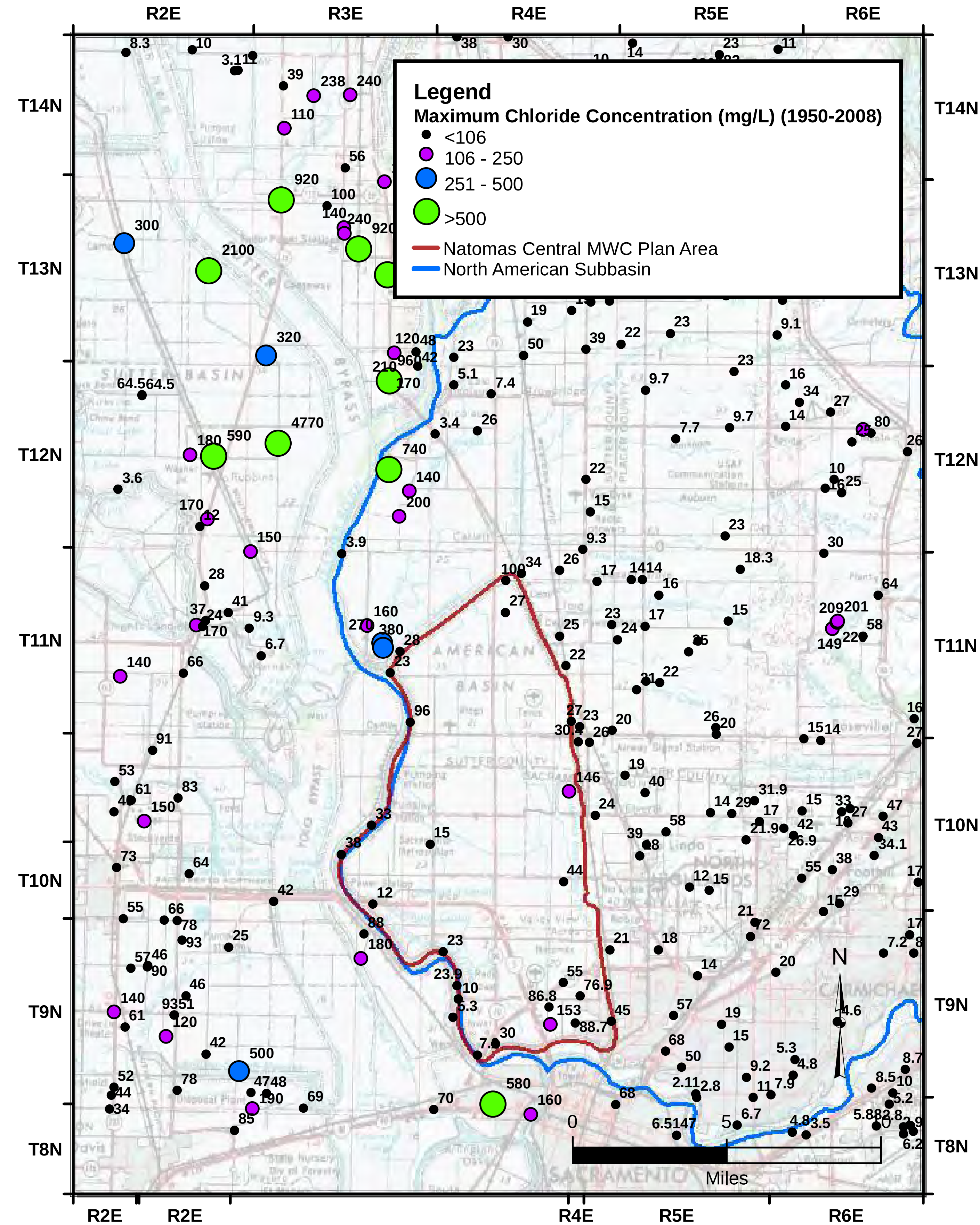

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Figure 12
Maximum Chloride Concentration
for Wells In and Near the Plan Area, 1950 to 2008

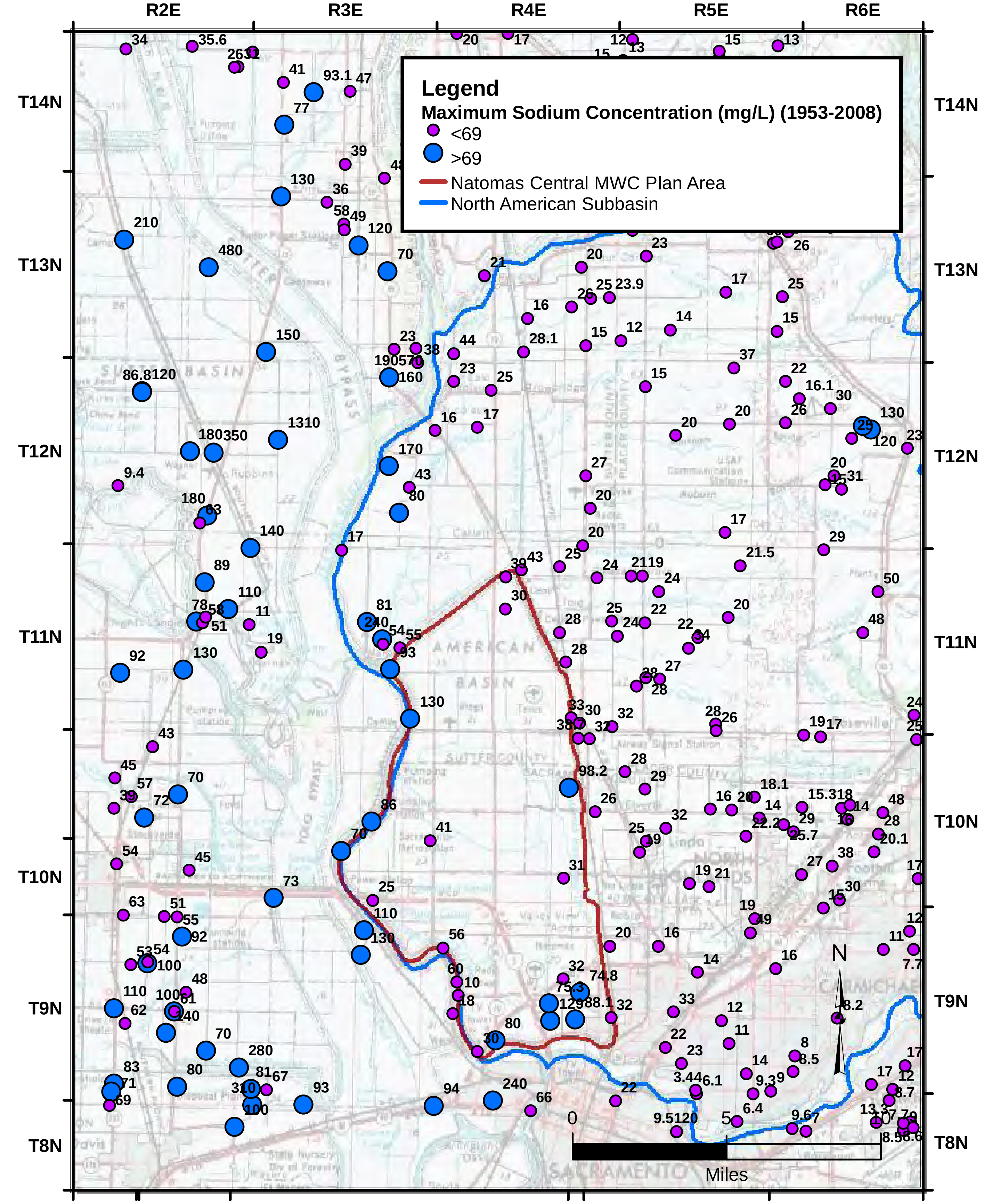

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Figure 13
Maximum Sodium Concentration for Wells In and Near the Plan Area, 1953 to 2008

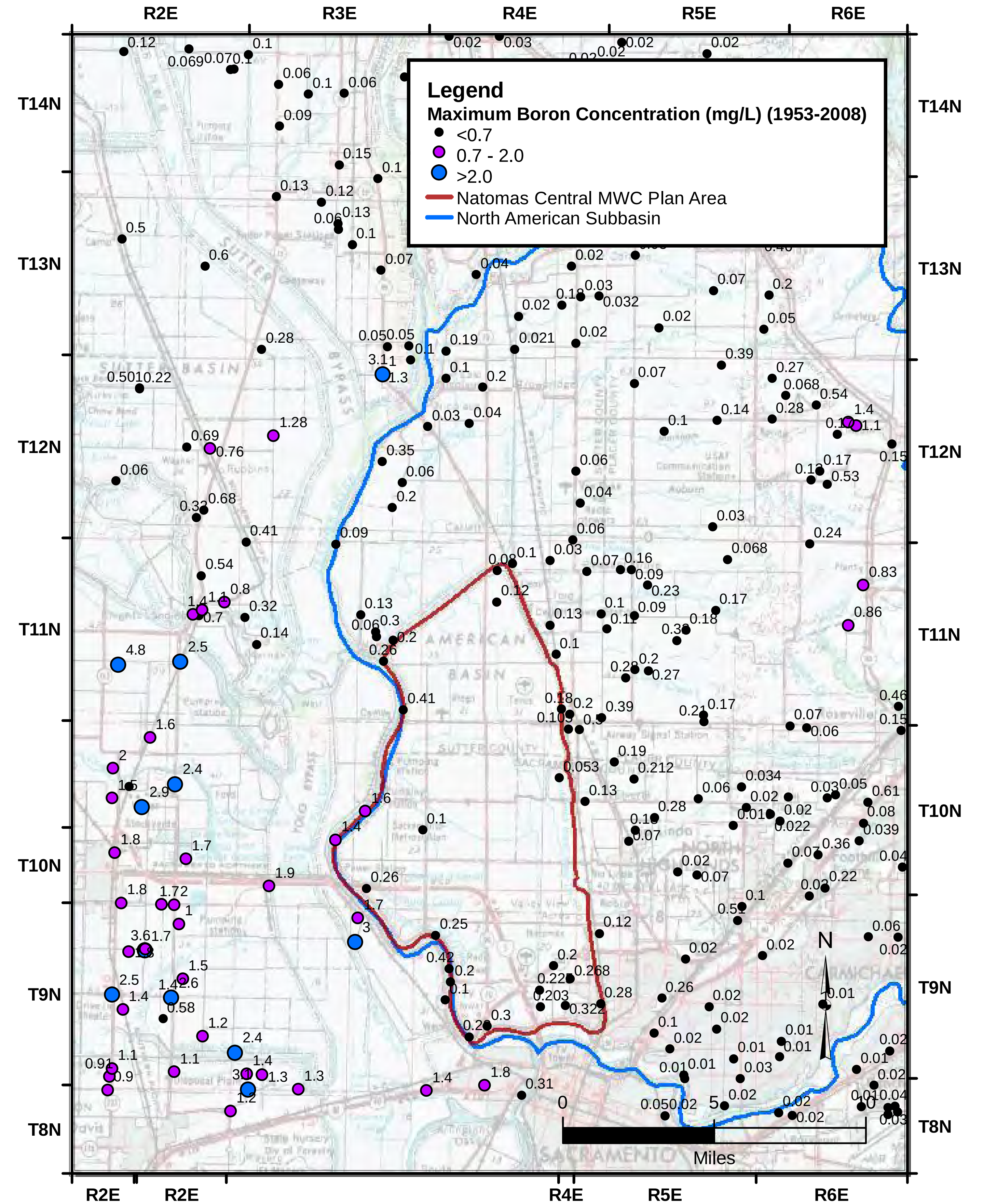

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Figure 14
Maximum Boron Concentration for Wells In and Near the Plan Area, 1953 to 2008

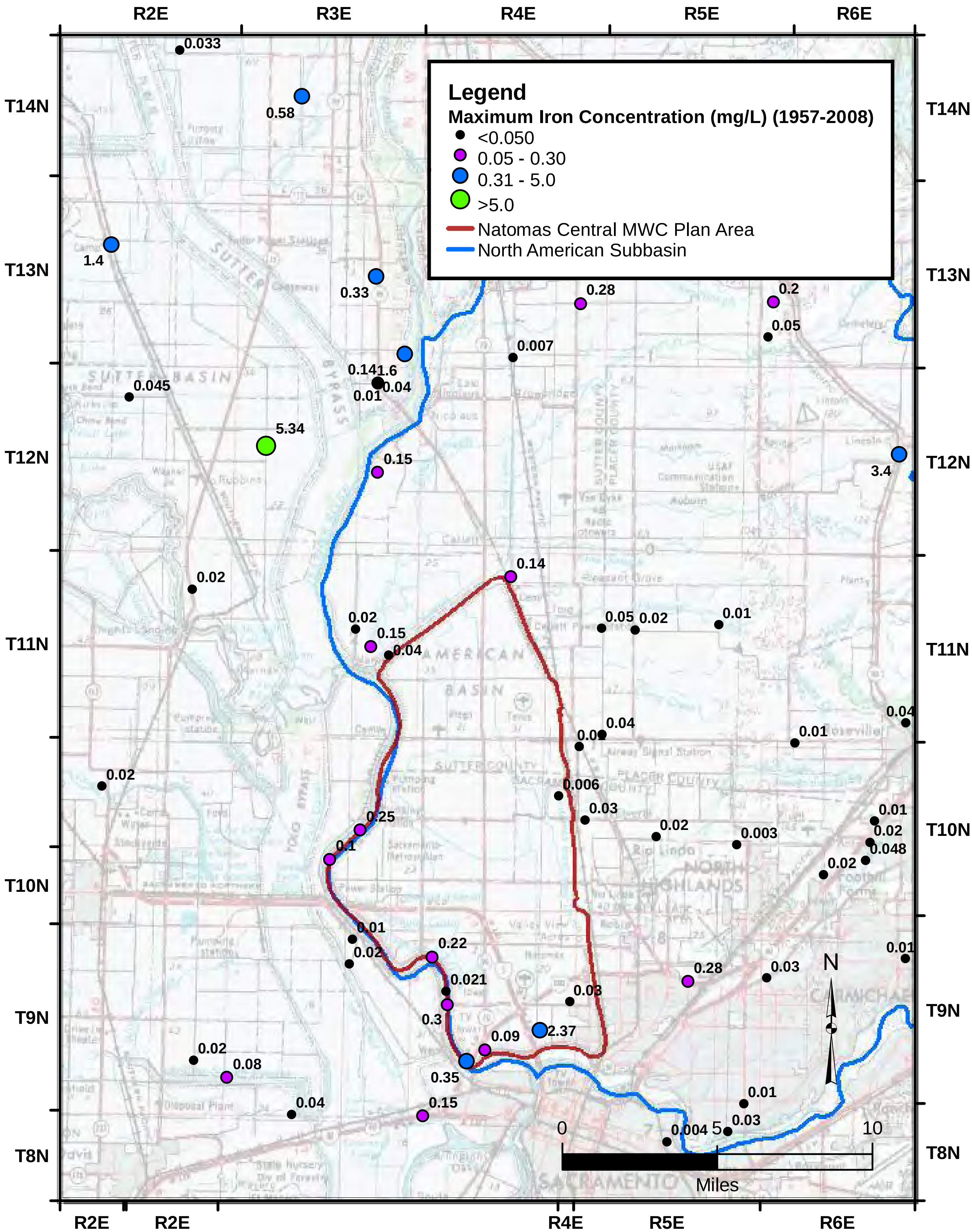

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Figure 15
Maximum Iron Concentration for Wells In and Near the Plan Area, 1957 to 2008

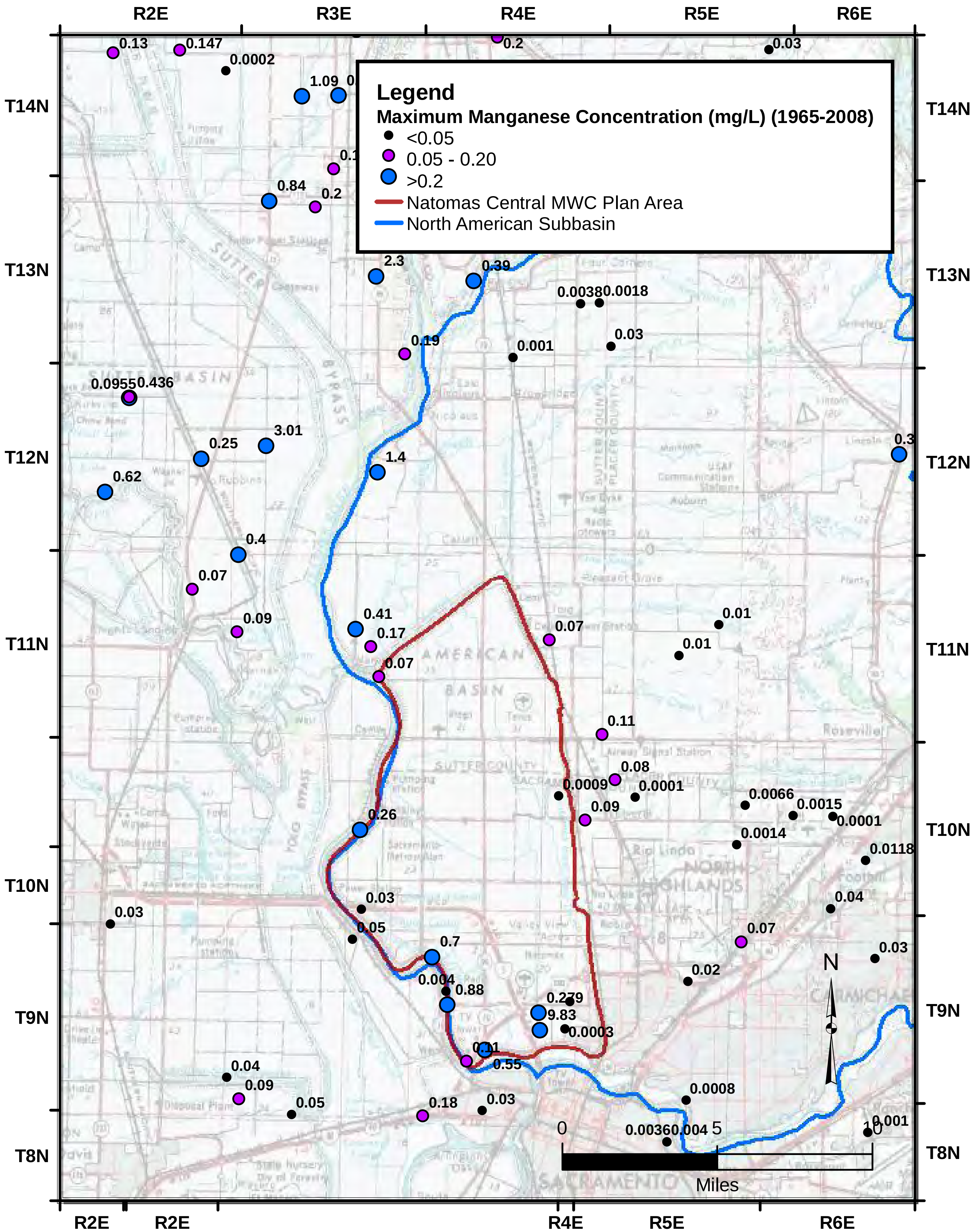

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Figure 16
Maximum Manganese Concentration
for Wells In and Near the Plan Area, 1965 to 2008

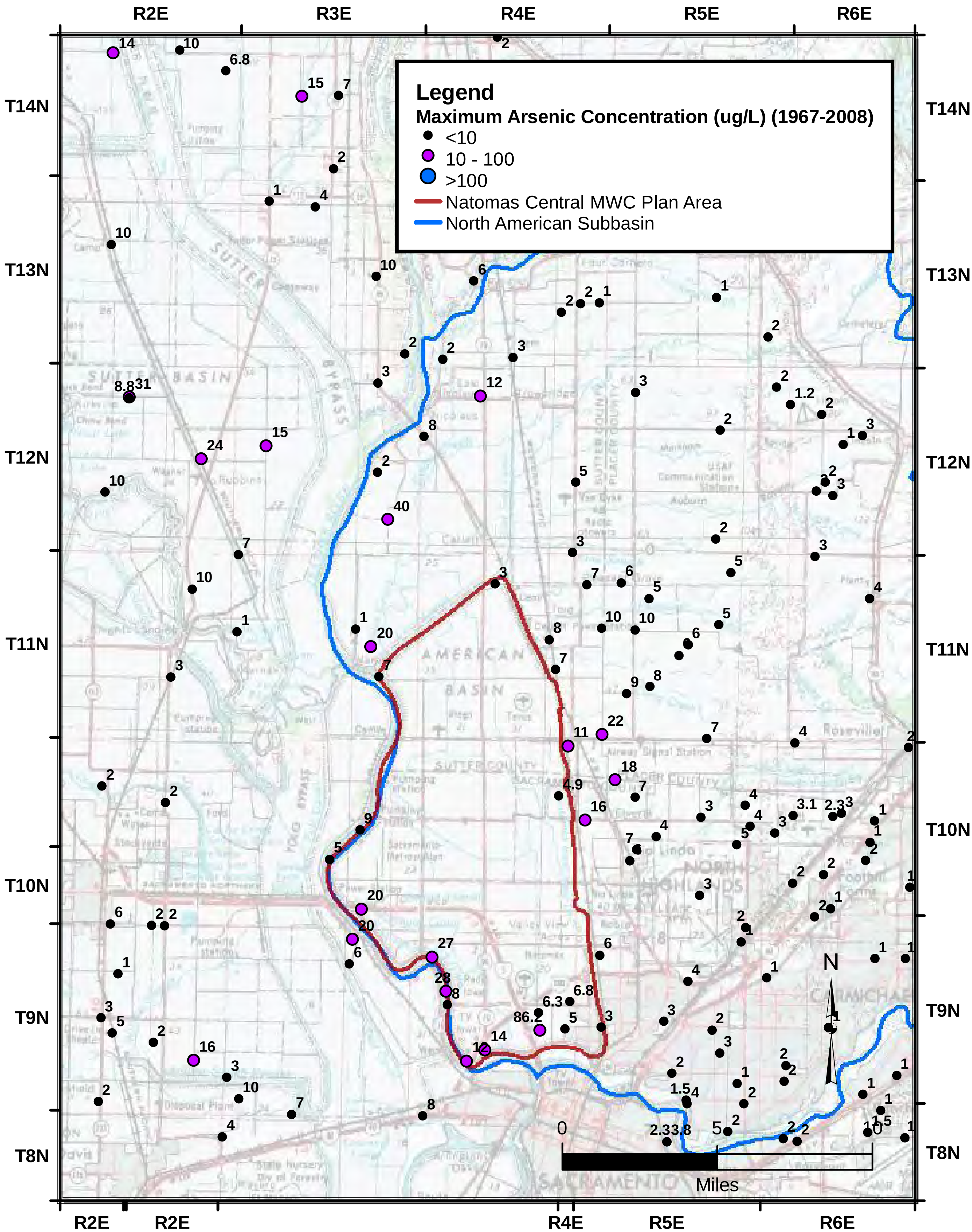

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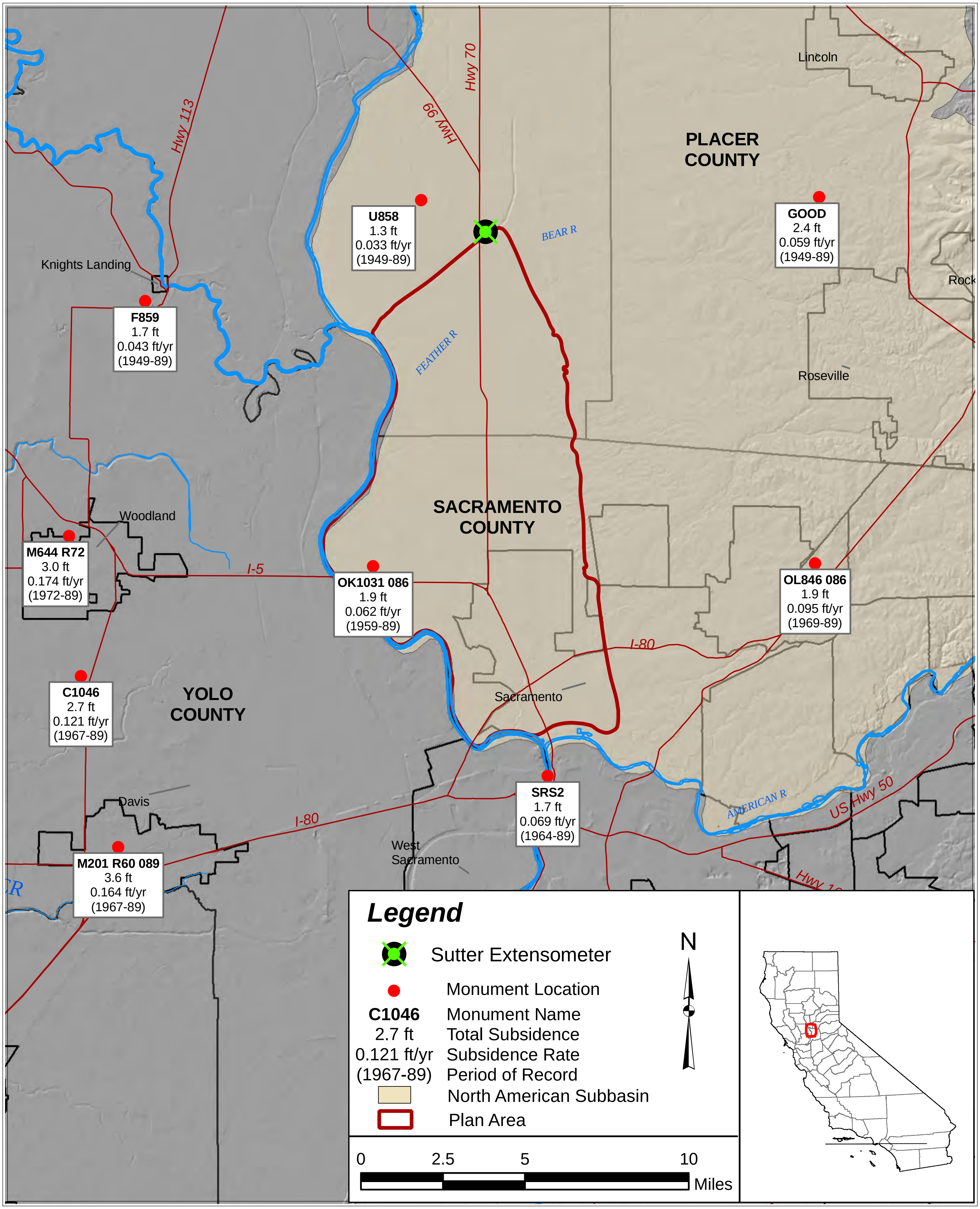
Figure 17
Maximum Arsenic Concentration for Wells In and Near the Plan Area, 1967 to 2008



FILE: \\server_pe2900\Public\Natomas Central\2009 Update\GIS\Figure 4-11 Total estimated Subsidence Rates.mxd Date: 6/23/2009

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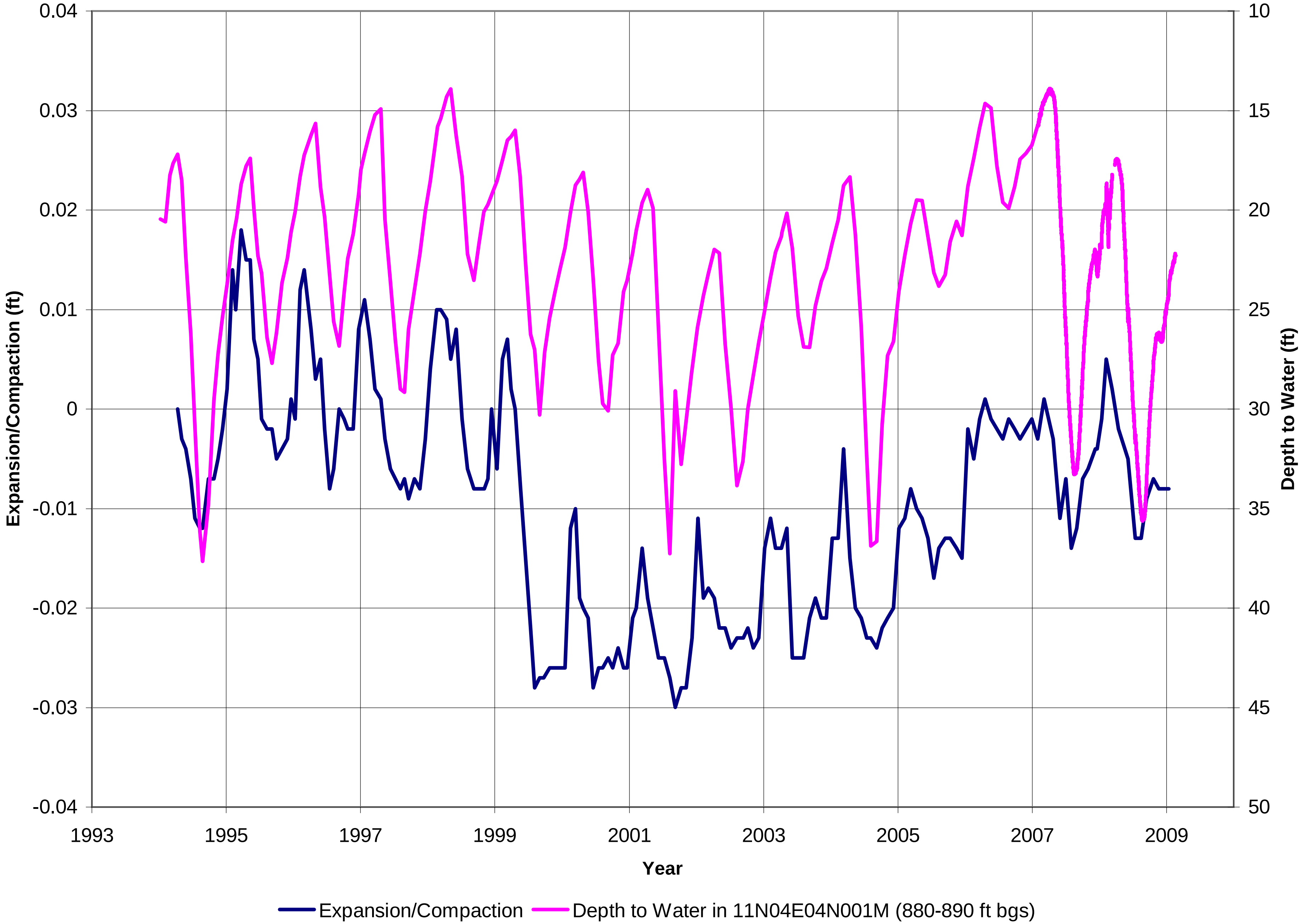
Figure 18
Total Estimated Subsidence and Subsidence Rates in Southern Sacramento Valley as of 1989



Y:\Natomas Central\2009 Update\subsidence\DWR_Data\Subsidence_DWR.xls\SutterExtensometer

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Figure 19
Compaction and Water Level Data for the Sutter Extensometer